PILOT-SCALE TREATABILITY TESTING
WORK PLAN
FORMOSA PLASTICS CORPORATION, TEXAS
POINT COMFORT, TEXAS

Prepared for:

FORMOSA PLASTICS CORPORATION
Point Comfort, Texas

June 28, 2013

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PBW Project No. 3281

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1.0 INTRODUCTION

In accordance with the U.S. Environmental Protection Agency (EPA) Administrative Order on Consent with Corrective Action Plan (CAP) dated February 27, 1991 (EPA Docket No. VI-001(h)-90-H; EPA I.D. No. TXT490011293), as amended, Formosa Plastics Corporation, Texas (FPC-TX) has undertaken measures to characterize and remediate soil and groundwater affected by volatile organic compounds (VOCs) at the Point Comfort facility. The FPC-TX facility is located in Calhoun County along State Highway 35 and Farm to Market Road (FM) 1593, adjacent to Lavaca Bay (Figure 1). The EPA's 1991 Order addresses a facility of approximately 256 acres.

As documented in the Final Risk Management Plan (RMP) (Tetra Tech, 2010), remaining Solid Waste Management Units (SWMUs) and associated potentially impacted soil and groundwater have been segregated into two distinct Areas of Concern (AOC) at the FPC-TX facility: AOC 1 – the former Waste Water Treatment Plant (WWTP) area located in the eastern portion of the site; and AOC 2 – the Vinyl Chloride Monomer (VCM) Process area located in the central portion of the facility. The location of each AOC is presented on Figure 2.

Corrective action objectives (CAOs) have also been developed for the site. The CAOs were presented in EPA's Performance Based Remedy Decision document (EPA, 2009), finalized in the Response to Comments/Final Decision Document (EPA, 2010), and discussed in detail in the Final Risk Management Plan (RMP) (Tetra Tech, 2010).

This document presents a work plan for conducting a pilot-scale treatability study at the VCM and former WWTP areas. The study will evaluate the following technologies:

1) In-situ chemical oxidation (ISCO); and
2) Dual-phase extraction (DPE) and removal.

Additional background information and details on the pilot-scale treatability testing design are provided in the following sections of this work plan.

2.0 BACKGROUND

2.1 Conceptual Site Model

Soil and groundwater affected by volatile organic compounds (VOCs) are present at Formosa's Point Comfort facility. A comprehensive summary of existing environmental data was provided in the Areas of Concern Characterization Work Plan (Tetra Tech, 2012) and is not reproduced here. The RMP (Tetra Tech, 2010) also includes a detailed discussion of the nature and extent of potential soil and groundwater impacts and a conceptual site model (CSM). Both of the summaries mentioned above describe the results of the RCRA Facility Investigation (RFI) (C-K Associates, Inc., 1995) and the results of groundwater sampling that has been performed on a quarterly basis at the site since 1993. Additional soil and groundwater data were collected during 2012 at AOC 1 and AOC 2 as described in the AOC Characterization Report (PBW, 2012b). Additional soil and groundwater characterization is currently being conducted at AOCs 1 and 2 and the results will be described in subsequent reports.

The facility is underlain by Holocene alluvium and the Pleistocene-age Beaumont Formation. The Beaumont Formation consists chiefly of clay with interbedded silt, sand, and gravel with accumulations of calcium carbonate and concretions of iron oxide and iron magnesium oxides in the zone of weathering. These deposits originated as interdistributary muds, abandoned channel-fill muds, fluvial overbank muds, meander belts, levees, crevasse splays, and distributary sands. The clays in the Beaumont Formation are of low permeability, low shear strength, high compressibility, high water-holding capacity, high plasticity, and high to very high shrink-swell potential.

The conceptual model of groundwater flow includes three primary water-bearing zones at the facility (Zones A, B, and C). In addition, a laterally discontinuous perched zone (Zone P) is also present at some locations, specifically in the western portion of the VCM area. The relationships between the various water-bearing units are shown on hydrogeologic cross sections included the AOC Characterization Report (not reproduced here).

Zone A consists of interbedded sand, silt, and clay sediments characteristic of overbank flood-basin depositional environments. Sand/silt strata also occur in Zone A as sublinear, branching sand-rich bodies, which are representative of fluvial-deltaic and channel deposits. The base of Zone A typically occurs at an elevation of approximately 0 feet mean sea level (msl) and the unit ranges in thickness from a few feet to as much as 10 feet. Groundwater occurs under both confined and unconfined conditions in Zone A. The direction of groundwater flow in Zone A is generally to the southeast. The hydraulic gradient of Zone A groundwater is approximately 0.005 ft/ft.

Zone B is typically separated from Zone A by a varying thickness of fine-grained clay/silt strata. Zone B consists of fining-upward or massive sequences of silty sand to well-graded sand, as well as some finer-grained sediments. Zone B sand strata are characteristic of dominantly fluvial depositional environments, with adjacent floodbasin and interdistributary deposits. The base of Zone B typically occurs at an elevation of approximately -20 feet msl, though it can occur much deeper. The thickness of the Zone B sand and silt sequences range from less than 1 foot to greater than 20 feet. In some areas Zone B appears to be discontinuous, although this may be a function of the limited number of wells and borings in some areas. The Zone B sand/silt sequence appears to "pinch out" south of the VCM Process Area and was not encountered on the former Brookings Property (PBW, 2012b). Zone B occurs below sea level and groundwater occurs under confined conditions. The direction of groundwater flow in Zone B is generally to the southeast. The hydraulic gradient of Zone B groundwater is approximately 0.003 ft/ft.

Zone C is typically separated from Zone B by a varying thickness of fine-grained clay/silt strata and is the deepest transmissive zone identified at the site. Zone C consists of fining-upward or massive sequences of silty sand to well-graded sand and gravel. Based on borings completed to the apparent base of Zone C, the thickness of Zone C is on the order of 50 feet. Zone C groundwater occurs under confined conditions.

The main constituent of potential concern (COPC) identified in site soil and groundwater is 1,2-Dichloroethane (EDC). Other chlorinated hydrocarbons are also present in soil and groundwater samples at lower concentrations. Although EDC concentrations, and occasionally chloroform concentrations, exceed 1% of the aqueous solubility limit in some groundwater samples, and EDC concentrations exceed the soil saturation concentration (C_{sat}) in some soil samples, dense non-aqueous phase liquids (DNAPLs) have not been observed in monitoring wells at the site.

In the RMP and AOC Characterization Report, the Texas Risk Reduction Program (TRRP) protective concentration levels (PCLs) were used as a screening tool and compared to site soil and groundwater data. Contaminant concentrations in excess of the TRRP PCLs have been measured in soil and groundwater samples collected at six inactive SWMUs. Therefore, these areas represent the primary impacted areas at the site:

- SWMU #1 – Storm Water Basin;
- SWMU #21/22/23 – Inactive units adjacent to the active incineration area;
- SWMU #3 – Surge Basin; and
- SWMU #4 – Emergency Basin.

2.2 Bench-Scale Treatability Studies

Bench-scale treatability studies were performed at the Site in 2012 per a Bench-Scale Treatability Testing Work Plan (PBW, 2012a). The results of the testing were reported in the Bench-Scale Treatability Testing Report (PBW, 2013). Based on the specific characteristics of the site (e.g., groundwater quality, concentrations of COPCs in soil and groundwater, subsurface conditions, logistical issues, etc.), three remediation technologies were implemented for treatability testing: 1) in-situ chemical oxidation (ISCO), 2) enhanced bioremediation, and 3) multi-phase extraction (MPE) [1] (which is a combination of soil-vapor extraction (SVE) and groundwater extraction). Bench-scale testing was chosen to initially evaluate the ISCO and enhanced bioremediation technologies. Multi-phase extraction is not typically performed at the bench-scale level and was therefore performed as a short-duration pilot-scale test. A detailed description of these technologies is provided in PBW, 2012a and PBW, 2013.

For the bench-scale tests, samples of site soil and groundwater were collected from the WWTP Surge Basin/Emergency Basin area and shipped to the off-site laboratories where the bench-scale ISCO and enhanced bioremediation technologies were tested. A one-day DPE test was performed at wells P-56, P-57, and RS-6 east of the WWTP Surge Basin/Emergency Basin.

The results of post-test chemical analyses of the soil and groundwater indicate that all three ISCO reagents that were tested (Modified Fenton's Reagent (MFR), alkali-activated sodium persulfate, and heat-activated sodium persulfate) were effective at treating EDC and other VOCs detected at the site. The maximum EDC and total VOC reduction was greater than 99% in both the solid and aqueous phases. Destruction of EDC was greater at the higher reagent doses, as would be expected. However, the reduction in EDC/VOC concentrations in both the solid and aqueous phases was very limited for both the low-dose persulfate applications, but this was not the case for the low-dose MFR application. Given the site characteristics, contaminant mass reduction at the site will likely come from a cumulative effect of multiple low-dose ISCO applications (as opposed to one medium- or high-dose application). Therefore, it does not appear that multiple low-dose applications of activated persulfate will lead to cumulative contaminant mass reduction at the site. Rather, multiple low-dose applications of MFR should produce a cumulative contaminant mass reduction. Based on these conclusions, a field pilot study using MFR as the oxidant was recommended.

[1] Multi-phase extraction is also referred to as dual-phase extraction (DPE) in this report.

The enhanced bioremediation treatability test did not result in significant reductions in EDC concentrations in the bench test samples over a period of 99 days. The low rate of EDC destruction was likely due to the high concentrations of EDC and other VOCs present in the samples, which were toxic to the natural microbes present. Furthermore, bioaugmentation of the samples with common bacterial cultures during the bench test did not result in significant reductions in EDC concentrations. Further evaluation of enhanced bioremediation was not recommended.

The DPE pilot test results indicated that SVE alone is not viable at this site due to the relatively low permeability of the soils at the site. In the pilot test, the application of a high vacuum increased the groundwater level in the well, precluding the removal of vapor phase contamination from the vadose zone. The average mass of hydrocarbons removed was approximately ten times greater with the high-vacuum DPE than with SVE alone. Although the low permeability of the soil at the site reduces overall effectiveness, the relatively high volatility of EDC and the other hydrocarbons present at the site make these contaminants viable candidates for remediation via DPE. Further evaluation of DPE was recommended in the form of a pilot-scale test of longer duration (e.g., three days).

2.3 Objectives

Consistent with the CAOs developed for the site, Formosa seeks to develop an efficient and economical approach to remediation at the facility that integrates soil and groundwater remediation technologies that are proven to be appropriate for the site. The primary objective of the pilot-scale testing presented in this work plan is to gather the data sufficient to allow for full-scale design of a soil and groundwater remediation program for the site. The two pilot-scale tests will be conducted separately but data from the tests will be evaluated holistically to achieve the primary objective. In other words, the testing described in this work plan will be used to develop the appropriate remediation program considering the primary relevant site characteristics (i.e., thin unsaturated zone, multiple groundwater-bearing units, subsurface heterogeneity, the contaminants present, the potential presence of DNAPL, etc.). Furthermore, revisions or alterations to the proposed program can be made during implementation if data collected during the program or during other site investigations indicates the need to do so.

Specific objectives for the ISCO pilot-scale test are as follows:

- Determine the effectiveness of MFR at reducing contaminant mass present in the saturated zone soils and groundwater within the treatment areas;
- Determine site specific injection pressures, flow rates, radius of influence, and reagent volumes;
- Collect injection and analytical data that can be used to design a full-scale ISCO remediation program for the site, if necessary.

Specific objectives for the DPE pilot-scale test are as follows:

- Determine the effectiveness of DPE at reducing contaminant mass present in the saturated zone soils and groundwater within the treatment areas;
- Determine the optimal vacuum and flow rate conditions;
- Collect analytical data that can be used to design a full-scale DPE remediation program for the site, if necessary.

2.4 Testing Locations

Based on the existing site soil and groundwater data and the results of the bench-scale treatability tests, further testing of ISCO (using MFR) and DPE is proposed at two separate areas at the facility: 1) the WWTP Surge Basin and Emergency Basin area (hereafter called Area 1); and 2) an area southeast of the VCM area near well P-3/D-3 (hereafter called Area 2). Area 1 was selected as a test location because high concentrations of EDC and other VOCs have been measured in soil and groundwater in this area and the area is most likely to require remediation at the facility. Furthermore, the soil and groundwater samples used for the bench-scale testing program were collected in this area. Area 2 was selected because, although the concentrations of EDC and other VOCs are lower than at Area 1, the concentrations are still elevated and will likely require remediation. Furthermore, the lower concentrations at Area 2 will allow for the technologies to be tested at a range of concentrations and therefore provide a broader understanding of the applicability of the technologies for the site. Finally, these areas are in easily accessible portions of the facility. The exact locations of the tests are subject to underground and aboveground utility clearances, equipment access at the time of the tests, etc. Additional details on the two pilot-scale treatability tests is provided in Section 3.0 of this Work Plan.

2.5 Site Limitations

Site characteristics limit the potential success of traditional remediation technologies that are appropriate for the contaminants at the site (i.e., EDC and other VOCs). In particular, the heterogeneous nature of the subsurface stratigraphy, the presence of low-permeability clay units in the shallow subsurface, and the high concentrations of EDC and other VOCs create challenges for the implementation of ISCO and/or DPE at the site.

For ISCO, the presence of low-permeability clay overlying the confined saturated treatment intervals and the high concentrations of dissolved EDC present potentially challenging conditions for the implementation of the MFR technology at the site. The overlying clays within each treatment zone may prevent the uniform migration of produced gases into the vadose zone. This restriction can cause gasses to accumulate within the treatment zones and potentially lead to the upward migration of gasses, groundwater, and reagent through preferential pathways (historic probe holes, annular space around well casings, and/or natural fissures) to the ground surface (a process referred to as surfacing). Additionally, the relatively high concentrations of EDC present at the site will require the injection of large volumes of reagent into the subsurface, which also increases the potential for surfacing. These factors have been taken into account when developing the proposed pilot-scale ISCO test described below. The design consists of the use of multiple injection locations within each treatment area and the use of several injection events in order to deliver sufficient quantities of reagent into the subsurface and at the same time limit surfacing. Sampling of soil and groundwater at the test areas before, during, and after the tests will allow for a comprehensive evaluation of the potential for remediation of site soil and groundwater via the selected technologies.

For DPE, the relatively low permeability of the subsurface units (both clay and sand) is a limiting factor because vapor and groundwater will move through the subsurface at rates that are less than optimal for the removal of large masses of contaminants. These limitations have also been considered in the development of the DPE pilot-scale testing program.

3.0 TREATABILITY STUDY DESIGN

3.1 Introduction

As discussed above, based on the specific characteristics of the site (e.g., groundwater quality, concentrations of COCs in soil and groundwater, subsurface conditions, logistical issues, etc.), and the results of the bench-scale studies, two remediation technologies will be implemented for pilot-scale treatability testing (ISCO and DPE). These technologies have the potential to help meet the corrective action objectives (CAOs) and remediation goals for the site.

The following sections describe the pilot-scale treatability testing program designed to evaluate the selected remediation technologies.

3.2 In-Situ Chemical Oxidation (ISCO)

In-situ chemical oxidation (ISCO) uses strong oxidants to reduce the concentrations of targeted contaminants to acceptable levels. ISCO is accomplished by injecting or otherwise introducing the oxidants directly into the contaminated medium (soil or groundwater) to destroy chemical contaminants in place. Chlorinated ethanes such as EDC are amenable to destruction by chemical oxidation and ISCO is potentially an effective treatment method for soil and groundwater impacted by EDC at the site.

This technology is mainly applicable for saturated media including soil and groundwater; however, in some cases ISCO can be configured to address unsaturated soil by artificially saturating the vadose zone to permit treatment. For the proposed pilot-scale test, the two uppermost saturated Zones A and B will be tested. Given the relatively thin vadose zone present at the test areas, the effect of ISCO on contaminants in vadose zone soil will by default be evaluated through the collection of soil samples before, during, after the tests.

As described above and per the results of the bench-scale tests, MFR was selected as the preferred oxidant for the pilot-scale test. In-Situ Oxidative Technologies, Inc. (ISOTEC) of Arvada, Colorado prepared the work plan for pilot-scale testing (Appendix A).

Pilot-scale ISCO tests will be conducted at Areas 1 and 2 as shown on Figure 2. At each area, temporary direct-push injection screens will be installed to introduce the MFR into the subsurface. Monitoring wells will be installed within each area to allow for the collection of groundwater samples before, during, and after the test. The locations of the monitoring wells relative to the injection points are shown in Appendix

A. Soil samples will be collected from borings within each of the treatment areas and analyzed for VOCs including EDC. A minimum of six samples will be collected from each treatment area. Three injection phases will be conducted within each area. Each phase will include an injection phase, a data collection phase, and an evaluation phase. ISOTEC will inject hydrogen peroxide and a buffered ferrous iron complex catalyst in each of the injection points during each phase. During each injection event, samples of groundwater will be collected for laboratory analysis and field measurements of various groundwater parameters will be also be conducted. A detailed description of the test design is provided in Appendix A.

ISOTEC will prepare a study report documenting the results of the tests.

3.3 Mass Removal Pilot Testing

DPE is a proven contaminant mass removal technology for highly contaminated source areas such as those identified at the site. Dual-phase extraction removes contaminants from both groundwater and vadose soils. Extraction from the vadose zone alone is called soil vapor extraction (SVE). Dual-phase extraction can be successful in a low permeable, low yield, heterogeneous formation such as that at the FPC-TX site and can achieve high contaminant mass removal rates. A dual-phase extraction system at the FPC-TX site could potentially remove a substantial portion of the contaminant mass in a relatively short period of time, thus reducing the overall remediation cost.

Gainco Inc. (Gainco) performed a one-day mass removal test previously as described in PBW, 2013. The results of the one-day test indicated that significant EDC mass could be removed using this technology and that a longer-duration (Phase II) test was appropriate to further evaluate the use of DPE for remediation of site soil and groundwater. The DPE test will focus on the vadose zone and Zone A groundwater at the test areas. A work plan for a pilot-scale DPE test is provided in Appendix B.

The test will be performed at Areas 1 and 2 as described in Gainco's work plan in Appendix B. At each area and for each test, groundwater and soil vapor will be extracted from two extraction wells simultaneously while monitoring of subsurface conditions is performed in four monitoring points. Background data consisting of groundwater level and barometric pressure measurements will be collected at each area prior to each test. Soil samples will be collected from borings within each of the treatment areas and analyzed for VOCs including EDC. A minimum of six soil samples will be collected from each treatment area. The tests will be conducted over a two-day period at each area. The DPE pilot test activities will be performed in a series of step tests in the extraction wells, whereby for a period of approximately 6-8 hours, the vacuum will be increased in step fashion. Once the maximum extraction vacuum is reached, a DPE test will be conducted until approximately 48 hours has elapsed.

During the step testing, the following parameters will be observed and recorded:

- Vacuum at the pumps, wells, monitor points and any nearby wells (as appropriate);
- Extracted soil vapor organic compound concentration;
- Exhaust air flow, exhaust temperature, and exhaust pressure;
- Groundwater levels in designated monitor points and/or nearby monitor wells to evaluate the aquifer response to DPE over time.

Soil vapor samples will be collected for laboratory analysis at the beginning of each DPE step for analysis of VOCs including EDC. One sample will be collected at the beginning of the high vacuum DPE test and every five hours thereafter for VOC analyses to determine hydrocarbon recovery over time.

Gainco will provide a summary report that will include the pilot test data, analysis, and results. The report will include the estimated amount of hydrocarbon removed, soil vapor and groundwater recovery rates, hydraulic characteristics, subsurface vacuum profile, and a general evaluation of the viability of the DPE technology as a remedial option for the site.

3.4 Scheduling

The DPE pilot-scale test will be conducted at each area first, followed by the ISCO tests. The ISCO tests will be conducted adjacent to the DPE test areas, i.e., not at the exact locations. The DPE test is expected to take less than one week. The ISCO test will take approximately three months to complete. Injection events take place approximately one month apart. In between the injection events, the area is sampled, the samples are analyzed, and the data are reviewed prior to the next injection event.

3.5 Documentation and Reporting

All field activities will be documented by logging events on field records, log sheets, etc. and by collection of photographs. Boring logs will be prepared for each boring installed, including lithologic descriptions of the soils observed. Chain-of-custody forms will be used to document sample shipping and custody. Each vendor will prepare a study report describing the test procedures and results, including all analytical data from the testing. The vendor reports will be appendices to a Pilot-Scale Treatability Study Report that will summarize the results of the study, present recommendations for further testing (if necessary), and/or provide general details regarding the potential for full-scale design of either of the technologies tested.

4.0 REFERENCES

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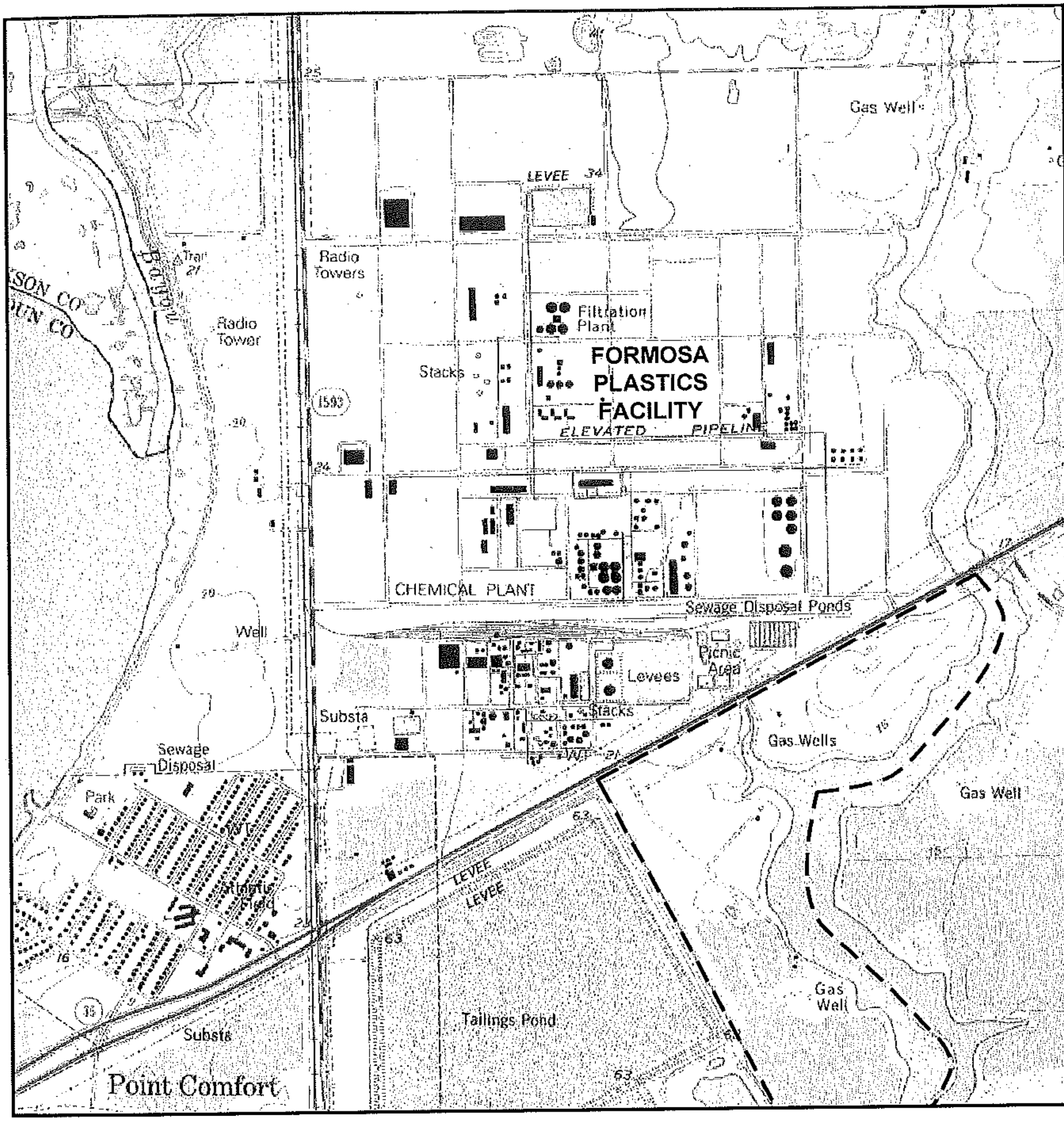
FIGURES



Contour Interval = 5 Feet

QUADRANGLE LOCATION

N

Scale in Feet

0 1000 2000

Source:
Base map from Point Comfort, Texas 7.5 min. U.S.G.S. quadrangle (1995).

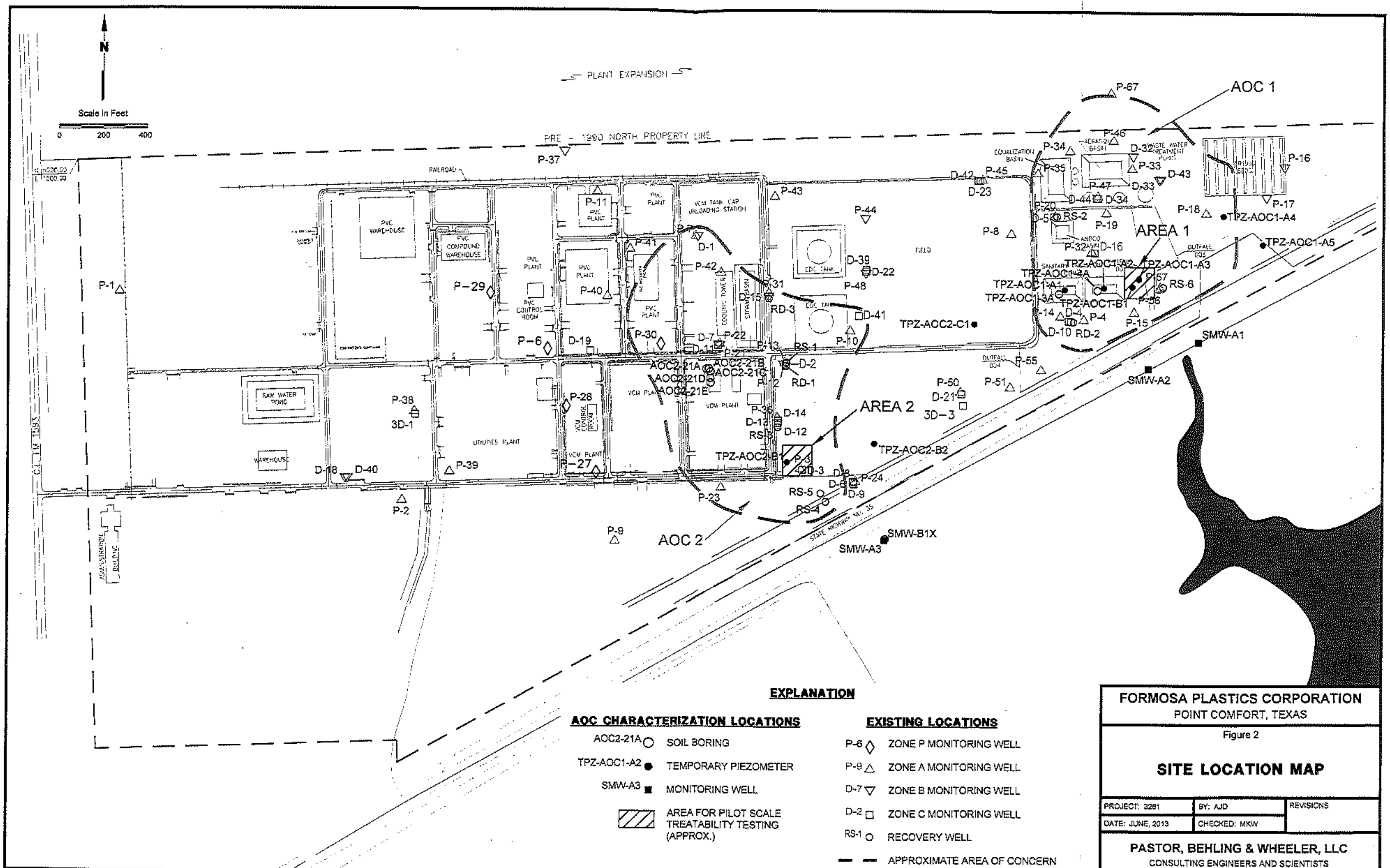
FORMOSA PLASTICS CORPORATION

Figure 1

AREA LOCATION MAP

PROJECT: 3281	BY: AJD	REVISIONS
DATE: JUNE, 2013	CHECKED: MKW	

PASTOR, BEHLING & WHEELER, LLC
CONSULTING ENGINEERS AND SCIENTISTS



FORMOSA PLASTICS CORPORATION POINT COMFORT, TEXAS	
Figure 2 **SITE LOCATION MAP**	
PROJECT: 3281	BY: AJD
DATE: JUNE, 2013	CHECKED: MKW
REVISIONS	
PASTOR, BEHLING & WHEELER, LLC CONSULTING ENGINEERS AND SCIENTISTS	

APPENDIX A

Pilot-Scale Treatability Testing Work Plan - ISCO

In-Situ Chemical Oxidation
Pilot Test Work Plan

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1.0 INTRODUCTION

In-Situ Oxidative Technologies, Inc. (ISOTEC) has been requested by Pastor, Behling, Wheeler, LLC (PBW) to implement an in-situ chemical oxidation (ISCO) pilot-scale testing program using ISOTEC's patented neutral pH modified Fenton's reagent-based technology (MFR) at the Formosa Plastics Corporation facility located at 201 Formosa Drive in Point Comfort, Texas (**Figure 1**). The facility is also referred to as "the site" in the remainder of this document.

This ISCO Pilot Test Work Plan details ISOTEC's approach for conducting the ISCO field injection activities at the site. Temporary direct-push injection screens will be utilized to introduce ISOTEC reagents into the subsurface. This approach will allow for optimal subsurface transport of ISOTEC reagents.

The ISCO pilot test program will have three planned injection phases (Phase 1A, 1B and 1C) and will be conducted within two separate treatment areas (Area #1 and Area #2). Each phase will include an injection phase, a data collection phase and an evaluation phase.

1.1 SITE CONDITIONS

According to data provided by PBW, saturated zone soils and groundwater at the site have been impacted by volatile organic compounds (VOCs). The primary contaminant of concern (COC) for the ISCO pilot test program is 1,2-dichloroethane (EDC). A review of groundwater data collected from site monitoring wells indicated that dissolved EDC concentrations have ranged from non-detect (ND) to as high as 1,800,000 micrograms per liter (µg/L).

Based upon data provided by PBW, the saturated soils within Zone A and Zone B are comprised of silty-sand to fine grained sand with some clay lenses. The Zone A aquifer varies in thickness from 5 to 10 feet and is encountered at varying depths from approximately 13 to 28 feet below ground surface (bgs). The Zone B aquifer is from 5 to 8 feet in thickness and is encountered at depths ranging from approximately 37 to 45 feet bgs. The horizons above, below and in between these two zones are primarily clay.

1.2 PROJECT BACKGROUND

In 2012, ISOTEC conducted a chemical oxidation bench-scale laboratory treatability study (study) on soil and groundwater (GW) samples collected from the site. The target constituents for the study were VOCs, specifically EDC. Reagents evaluated during the study were MFR and sodium persulfate activated with alkali (ASP-alk) and heat (ASP-heat). The objective of the bench-scale study was to evaluate the potential effectiveness of MFR, ASP-alk and ASP-heat in the treatment of EDC impacted soil and groundwater at the site.

Results of the bench-scale treatability study indicated that MFR, ASP-alk and ASP-heat were all effective at treating EDC. However, MFR proved to be more effective than ASP when the reagents were prepared at low dosages. Since field application of MFR and ASP often require low-volume injections in order to limit the upward migration of reagent to the ground surface, MFR was determined to be the preferred technology for field application at the site. Based on these conclusions, a pilot-scale testing program using MFR was developed as described in the following sections.

A detailed discussion of ISOTEC's patented neutral pH MFR technology (The ISOTEC Process) is included as **Attachment 1**.

PROJECT OBJECTIVES

The objective of the ISCO pilot test program is to demonstrate the effectiveness of the ISOTEC process in treating EDC within the treatment areas and determine injection parameters for use in full-scale design. Multiple groundwater samples have been collected and analyzed in the vicinity of the pilot test treatment areas with reported EDC dissolved concentrations ranging from 20,000 μg/L to 1,600,000 μg/L.

The specific objectives of the pilot test program using ISOTEC's Fenton's-based oxidation process are to:

- Determine the effectiveness of MFR at reducing contaminant mass present in the saturated zone soils and groundwater within the treatment areas;
- Determine site specific injection pressures, flow rates, radius of influence and reagent volumes;
- Collect injection and analytical data that can be used to design a full-scale ISCO remediation program for the site.

The pilot test is not intended to achieve specific remediation cleanup criteria in dissolved contaminant concentrations; it is intended to provide the site-specific parameters needed to design the full-scale ISCO application.

2.0 ISCO PILOT TEST PROGRAM

The pilot test design is based upon data supplied by PBW and is designed to address several potentially limiting factors to implementation success. Limiting factors at the site include clay overlying the confined saturated treatment intervals and the high concentrations of dissolved EDC (20,000 ug/L to 1,600,000 μg/L). These two factors present potentially challenging conditions for the implementation of MFR technology at the site. The overlying clays within each treatment zone may prevent the uniform migration of produced gases into the vadose zone. This restriction can cause gasses to accumulate within the treatment zones and potentially lead to the upward migration of gasses, groundwater, and reagent through preferential pathways (historic probe holes, annular space around well casings, and/or natural fissures) to the ground surface (a process ISOTEC refers to as surfacing). Additionally, the relatively high concentrations of EDC present at the site will require the injection of large volumes of reagent into the subsurface, which also increases the potential for surfacing. In order to achieve project success, these factors must be taken into account when an injection program is designed. The design, therefore, consists of the use of multiple injection locations within each treatment area and the use of several injection events in order to deliver sufficient quantities of reagent into the subsurface and at the same time limit surfacing.

2.1 ISCO PILOT TEST PROGRAM DESIGN

ISOTEC proposes to conduct the pilot test in two separate areas at the site: one area will be within a portion of the site that exhibits relatively high dissolved-phase concentrations, and the second area will be within a portion of the site with relatively low dissolved-phase concentrations. The high concentration treatment area will be located in the vicinity of monitoring wells P-56 and P-57 and piezometer well TPZ-AOC1-B1. This area will be herein referred to as Area #1, and is shown on **Figure 1** and **Figure 2**. The low concentration treatment area will be located in the vicinity of monitoring wells P-3 and D-3 and piezometer well TPZ-AOC2-B1. This area will be herein referred to as Area #2, and is shown on **Figure 1** and **Figure 3**.

Area #1 covers approximately 3,000 square feet (approximately 40 feet by 75 feet) and will target both Zone A and Zone B. Based on a review of the boring log for piezometer TPZ-AOC1-B1, the permeable layer within Zone A appears to be present from approximately 12 to 17 feet bgs and in Zone B from approximately 35 to 45 ft bgs in Zone B. Area #2 will cover approximately 3,000 square feet and will also target Zone A and Zone B. The boring log for piezometer TPZ-AOC2-B1 indicates that the permeable layer within Zone A appears to be present from approximately 18 to 28 feet bgs and in Zone B from approximately 39 to 42 ft bgs.

Three injection events are recommended for the pilot test program. Multiple injection events are needed to ensure sufficient mass removal to determine the effectiveness of MFR technology at the site and determine the total number of injection events needed for the full-scale application.

Remediation progress during the pilot test will be monitored by both soil and groundwater samples collected before, during and after the test. Six new monitoring wells will be installed within Area #1 (Figure 2) and six within Area #2 (Figure 3). ISOTEC recommends that the 12 monitoring wells be installed as pairs or clusters. Specifically, an A zone well and a B zone well will be installed immediately adjacent to each other (approximately 2 feet apart) at three different locations within each pilot test treatment area.

During each injection event (Phase 1A, Phase 1B and Phase 1C), ISOTEC will inject reagent at approximately six locations within Area #1 and six locations with Area #2. The number and spacing of the locations is based upon an anticipated 12-foot reagent distribution radius, based upon past experience with similar lithologies. At each location, one Zone A injection screen and one Zone B injection screen will be installed in separate boreholes using a DPT drill rig. Based upon the current understanding of site conditions, Zone A screens within Area #1 will be installed from 12 to 17 feet bgs and Zone B screens will be installed from 37 to 45 feet bgs. Within Area #2, Zone A screens will be installed from 20 to 28 feet bgs and Zone B screens will be installed from 37 to 42 feet bgs. However, the actual screen depths will be refined based on data collected during the installation of pilot test monitoring wells. This method of selective vertical injection will ensure reagent delivery across the entire vertical extent of the impacted saturated interval. The direct-push injection screen installation process is described in **Section 3.6** below.

Each injection event will require approximately three to five days of on-site field activities. Standard daily working hours on-site during the field activities will be 10 hours, plus weekends as needed.

3.0 FIELD IMPLEMENTATION

3.1 PRE-MOBILIZATION ACTIVITIES

ISTOEC assumes that prior to mobilizing to the site, PBW will obtain the necessary property access, permitting and utility clearances. Prior to mobilizing to the site a site specific Health and Safety Plan will be prepared (See **Section 6.0**).

3.1.1 Property Access Requirements

ISOTEC understands that PBW will obtain permission from property owners and adjoining property owners as well as complete public notification as necessary prior to injection activities.

3.1.2 Permits and Approval

ISOTEC understands that PBW will be responsible for the preparation and submittals of associated permits and approvals, as necessary, to implement the ISCO remediation program.

3.1.3 Utility Survey

During the ISCO remediation program, steps will be taken to ensure that the integrity of the utilities located at or near the treatment area are not disturbed by field activities. Utility verification and marking will be performed in accordance with the standard industry utility verification procedures. ISOTEC has assumed that PBW will be responsible for utility identification and marking prior to the initiation of direct-push injection activities.

3.2 MOBILIZATION

Mobilization activities include transportation and staging of ISOTEC equipment, materials, instruments, personnel and services required for implementing the program. The equipment that will be transported to the site will include two ISOTEC box trucks housing hoses, tanks, drums, a gas-powered air compressor and generator, electric mixers and pneumatic pumps. The materials that will be transported to the site will include hydrogen peroxide at a concentration of 30% and dry catalyst required for reagent preparation. The 30% hydrogen peroxide will be stored on-site in DOT-approved 55-gallon drums.

3.3 WATER SUPPLY

ISOTEC will use significant quantities of water during the ISCO pilot test. Specifically, up to 10,000 gallons of water will be needed during each injection event. ISOTEC has assumed that Formosa will be responsible for supplying the water required to prepare the reagents.

3.4 Reagent Preparation

ISOTEC oxidizer consists of a pre-determined concentration of hydrogen peroxide, water and stabilizer. As discussed in **Section 2.0** above, ISOTEC will utilize an oxidizer concentration of 12%. Hydrogen peroxide at a concentration of approximately 30% will be shipped directly to the site immediately prior to field injection activities and stored in Department of Transportation (DOT) approved 55-gallons drums. The 30% hydrogen peroxide will be diluted on-site to a 12% concentration. The 30% hydrogen peroxide will be diluted in 300-gallon bulk tanks with water obtained on-site. The ISOTEC series catalyst consists of a pH buffered (pH of approximately 7) ferrous iron complex. At post-reaction concentrations the iron complex is similar and comparable to naturally occurring metals within the soil matrix (i.e., ppm range). The catalyst will be shipped to the site in dry form and mixed on-site in 300-gallon bulk tanks with water obtained on-site. A reagent mixing schematic is included as **Figure 4**.

All reagents will be either injected during the mobilization or removed from the site at the completion of injections.

3.4.1 Material Handling and Storage

ISOTEC employees will handle and store hydrogen peroxide and catalyst to complete this project. All ISOTEC employees have received training in the proper handling and storage of these chemicals. They have also received specific training in the PPE required to handle these chemicals safely. A fire extinguisher and eye-wash station will be on-site in each box truck at all times.

Chemicals will be stored according to the requirements of the DOT. In brief, the hydrogen peroxide and the catalyst will be stored in such a way that if a spill were to occur, the two would not come into contact with each other. To accomplish this, the peroxide will be stored in a location separate from the catalyst. Specifically, the concentrated peroxide (maximum concentration of 30%) will be stored on-site in DOT-approved 55-gallon drums in a secure box truck. Diluting the peroxide will be performed in a dilution tank. Water will be added to the dilution tank along with dry stabilizer in a predetermined volume to create a 12% concentration after the addition of a predetermined volume of hydrogen peroxide. An electric drum pump or an air operated double diaphragm pump will be used to transfer the peroxide into the dilution tank. Two technicians are required to complete this process. One operates the pump and one holds the transfer wand in the dilution tank. Both technicians will wear splash resistant aprons, face-shields and chemical resistant gloves while completing the transfer.

Liquid catalyst and the dry chemicals necessary to mix it will be stored inside of a box truck. To mix catalyst, iron will be added to the mixing tank followed by a predetermined quantity of water. An electric mixer is used to mix the solution. ISOTEC's patented chelating agents are then added to the solution and mixing continues. Although the chemicals are non-hazardous and the mixing process is generally dust free, the technician completing the mixing will wear nitrile gloves and a NIOSH approved N95 particulate respirator as a precautionary measure.

Combustion issues associated with the presence of hydrogen peroxide, a strong oxidizer, are minimized since a maximum solution of 30% will be delivered to the site. The peroxide will be stored in DOT-approved 55-gallon drums. Flammable materials, i.e., gasoline, will not be stored near the peroxide or in locations where a peroxide spill could occur.

The ISOTEC reagents are not combined at the surface. The peroxide and catalyst only come into contact with one another in the subsurface. Precautions are taken by flushing all equipment with water between separate injections of each reagent.

3.4.2 Spill Prevention

Hydrogen peroxide and catalyst will be stored in such a way that if a spill of either were to occur, the two would not come into contact with each other. The tanks used to dilute the peroxide and to mix and store the catalyst are oversized to prevent spillage from the tanks. If a small spill, less than five gallons, of peroxide occurs to the ground surface water will be used to dilute it further and actions taken to prevent the fluid from entering any storm drains or drainage ditches, while the fluid is soaked up with clay sorbent. If a larger spill of peroxide occurs the same procedure will be followed and any excess liquid will be pumped into a clean empty storage tank. If a small spill, less than 5 gallons, of catalyst occurs it will be contained and soaked up with sorbent pads then placed in a steel or poly drum. If a large spill of catalyst occurs it will be contained and pumped into the storage tank with an air diaphragm pump. If a spill of dry catalyst occurs it will be swept up and placed in a poly bag.

If any spill occurs work will stop immediately until the spill is cleaned up and the cause of the spill is determined and corrected. All spilled materials will be disposed of properly.

3.5 Injection Screen Installation

ISTOEC will utilize DPT to install temporary injection screens at the site. A Texas-licensed environmental drilling subcontractor will use a direct-push rig to advance 1.5-inch diameter threaded steel rods to a desired depth within the target treatment interval. After a sufficient number of steel rods have been advanced into the subsurface to reach the desired depth, an ISOTEC designed injection screen will be lowered to the bottom of the rod string. While the injection screen is held in place, the rod string will be retracted to expose the screen to impacted soils in the target treatment interval. ISOTEC reagents will then be injected through the temporary injection screen and into the subsurface.

Two injection screens will be installed at each injection location within the treatment areas; one screen will deployed across Zone A and one screen will be deployed across Zone B. This method of selective vertical injection will ensure reagent delivery across the entire vertical extent of Zone A and Zone B. It is important to note that the actual target treatment intervals for Zone A and Zone B within each pilot test treatment area will be determined following the installation of the newly installed pilot test monitoring wells. A direct-push injection screen schematic is shown in **Figure 5**.

As discussed in **Section 2.1** above, ISOTEC anticipates completing injection activities at 4 injection locations (8 injection screens) per day. To accomplish this, ISOTEC will ensure that the DPT subcontractor has enough direct-push rods to have all 4 injection locations (8 injection screens) installed each day.

3.6 REAGENT INJECTION PROCEDURES

The following sections detail ISOTEC's procedures for the injection of reagents into the subsurface at the site.

3.6.1 Injection Equipment

Chemical application equipment consists of varying size storage containers, pneumatic double-diaphragm pumps, regulators, flow meters, 3/4-inch diameter (3/4") reinforced PVC tubing, valves, and cam-lock connectors. Transfer of the reagents from the storage and/or mixing containers to the point of injection will be performed via a double-diaphragm pump. Reagents are conveyed through 3/4" reinforced PVC tubing and connected to the probe rod with a wellhead containing ball valves, fittings and a pressure gauge.

3.6.2 Injection Method

Injection of reagents into the subsurface is a five-step process. ISOTEC will setup on an injection wellhead and inject water into the subsurface, followed by catalyst. Water will then be injected to flush the catalyst away from the injection screen. Following the water flush, ISOTEC will inject oxidizer into the subsurface. A final water injection is completed to flush the oxidizer from the injection equipment. This process is repeated for each injection screen. An injection method schematic detailing the injection method utilizing DPT is included as **Figure 6.**

It is important to note that if surfacing occurs during injections into a particular injection screen, the injection pump will be immediately shut off to limit the amount of liquid escaping to the surface. Additionally, the surfaced liquid will be immediately contained using absorbent and then collected using an industrial vacuum or a shovel. The collected liquid, soil and/or adsorbent will be properly containerized in 55-gallons drums.

3.6.3 Reagent Quantities

ISOTEC will attempt to inject between 200 and 600 gallons of reagent at each location. Specifically, ISOTEC will attempt to inject between 50 and 150 gallons of catalyst and between 50 and 150 gallons of oxidizer into each Zone A screen, and between 50 and 150 gallons of catalyst and between 50 and 150 gallons of oxidizer into each Zone B screen. It is important to note that the actual volume injected will depend upon the lithology, surfacing, injection flow rate, pressure and radial effects noted during injection.

Reagent quantities will be recorded on daily log sheets, which will be made available to PBW at the end of each working day.

3.6.4 Injection Rates and Pressures

Injection rates and volumes are interrelated to the reaction rates of hydroxyl radicals with the contaminants, the distribution of contaminants in the subsurface, and the rate of hydrogen peroxide decomposition. The rate at which reagents are injected into the subsurface is initially determined by the soil/aquifer characteristics. Based upon review of the provided data, ISOTEC expects injection flow rates between 1 and 3 gallons per minute (gpm) and injection pressures of between 10 and 40 psi.

Injection rates and pressures will be recorded on daily log sheets, which will be made available to PBW at the end of each working day.

3.7 FIELD MONITORING

During each injection event, ISOTEC will collect field groundwater measurements from pilot test monitoring wells.

Groundwater measurements will be collected from the pilot test monitoring wells prior to initiating injection activities (baseline). Groundwater measurements will also be collected on a daily basis at those pilot test monitoring wells located within the immediate vicinity of the daily injection locations. The groundwater in the monitoring wells will be measured for hydrogen peroxide, iron, temperature, conductivity, dissolved oxygen (DO), pH and oxidation reduction potential (ORP). Hydrogen peroxide and iron will be measured in the field using CHEMets colorimetric test kits. Temperature, conductivity, DO, pH and ORP will be measured using a down-hole YSI 556 multiprobe system. Field monitoring data will be recorded on daily log sheets, which will be made available to PBW at the end of each working day.

3.8 DIRECT-PUSH BORING ABANDONMENT

Following injection activities, the direct-push subcontractor will remove the direct-push rods and injection screen from the individual boring. The boring will then be slowly backfilled with 3/8-inch bentonite chips to approximately 1 foot bgs and then properly hydrated. Concrete will complete the final foot of the borehole. This technique of "capping" the hydrated bentonite with approximately one foot of concrete will allow the bentonite to swell out into the soil over time forming a tight seal because the overlying concrete will prevent the bentonite from swelling vertically. This method provides for an excellent seal across both the vadose zone and the saturated zone; therefore preventing fluids from migrating down through the vadose zone and also prevent gas bubbles from entering the probe hole in the saturated zone.

4.0 ISCO PILOT TEST PROGRAM MONITORING

The effectiveness of the ISCO pilot test program should be monitored with groundwater samples collected from newly installed groundwater monitoring wells placed at varying distances from the proposed pilot test injection locations within each treatment area. ISOTEC also recommends that a series of soil samples be collected within each treatment area.

4.1 GROUNDWATER

Assessment of the pilot test program will be performed by comparing the results of baseline EDC groundwater sample results collected prior to injection activities to the results of groundwater samples collected during confirmation events which will be scheduled approximately two weeks following each injection event.

Groundwater samples will be collected from six newly installed monitoring wells within Area #1 and six newly installed monitoring wells within Area #2.

The pilot test program monitoring wells will be constructed of 2-inch diameter schedule 40 polyvinyl chloride (PVC) flush thread casing, with 0.020-inch slotted PVC screen. Sections of solid 2-inch diameter PVC riser will complete the upper portion of the well with the final section cut with a pipe cutter six inches below the ground surface. The annulus of each well will be filled with 10-20 grade silica sand which will extend from the bottom of the borehole to approximately one foot above the top of the screen followed by hydrated bentonite (3/8-inch diameter pellets) to a depth of two feet bgs. The remainder of the borehole will be filled with concrete. The surface completion for each injection well will be constructed in a minimum of a 12-inch diameter steel traffic box set in concrete. An ISOTEC monitoring well construction diagram is included as **Figure 5**.

Groundwater samples will be collected from the Area #1 and Area #2 monitoring wells prior to injection activities (baseline) and following completion of each event (post-first event, post-second event and post-third event) in order to evaluate treatment effectiveness. The samples will be analyzed for the following parameters:

- VOCs including EDC;
- Sulfate
- Nitrate
- Total Organic Carbon
- Alkalinity

As described in Section 3.7, field measurements of pH, ORP, alkalinity, temperature, turbidity, and dissolved oxygen will be collected during each before, during and after each injection event. Test kits will be used to measure hydrogen peroxide and iron concentrations.

4.2 SOIL

Soil data will also be used to evaluate the performance of the remediation program. The baseline soil samples will be collected no earlier than one month prior to the Phase 1A injection event. ISOTEC recommends that samples will be collected within both Area #1 and Area #2 at two to four depth intervals per location, depending on the thickness of Zone A and Zone B. Three locations will be sampled within each treatment area for a total ranging from 6 to 12 samples within each pilot test area. The sample locations will be marked with stakes and surveyed so that samples can be collected at the same location and sample depth(s) during subsequent performance monitoring events.

It is also important that each of the soil boring locations be plugged with bentonite chips and patched with concrete (approximately 6-inches) by the drilling subcontractor immediately after the collection of the soil samples to limit the potential for surfacing.

5.0 REPORT PREPARATION

Upon completion of the field test and receipt of all analytical data collected, ISOTEC will submit a report outlining details of the field test program. The report will detail the in-situ chemical oxidation process, field activities, and chemical analyses. Specifically, the ISOTEC reagent injection quantities, injection pressures, and injection rates will be discussed in the report and presented in tables. ISOTEC will discuss in detail analytical data obtained during the field test. Contaminant concentrations from baseline to post-injections will be discussed in the report, tabulated, and presented in figures. Finally, ISOTEC will discuss recommendations for full-scale treatment applications at the site.

6.0 HEALTH AND SAFETY PLAN

A site-specific health and safety plan (HASP) for the project will be prepared by ISOTEC. The ISOTEC HASP will be followed during the implementation of activities described herein. A typical ISOTEC injection team consists of a field supervisor, along with 1-2 field technicians. All members of the injection team have completed health and safety training consistent with the Occupational Safety and Health Act (Title 29 of the Code of Federal Regulations 1910.120) and have current certifications. The site supervisor has completed an additional eight hours of OSHA training. The HASP shall be revised and/or updated to reflect site conditions and activities, as necessary.

ISOTEC personnel will create a work zone around the injection pathway system and monitoring wells as part of their standard field operating procedures, with minimal site disturbance required. All injection and mixing activities will take place within this area, if possible. Reagents will be prepared on-site. Additional chemical storage precautions during non-working hours, such as an on-site lockable container (box truck) will be supplied to minimize any possible contact. Personnel protective equipment (PPE) will consist mostly of chemical splash attire and items noted in the HASP. The site-specific HASP will be available on-site during all field operations.

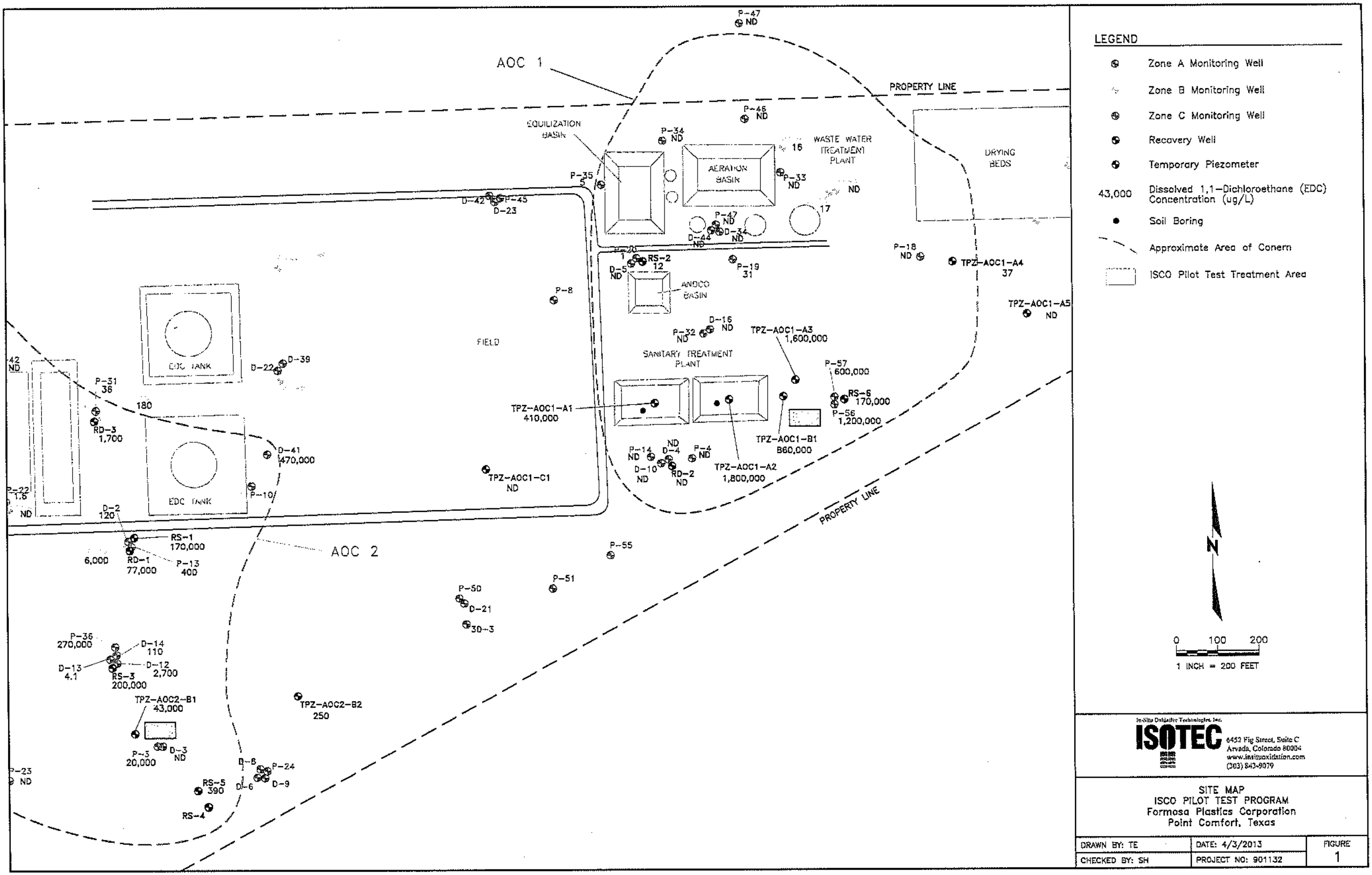
The ISOTEC process was created based on numerous years of both academic and private research in the chemical oxidation field. ISOTEC personnel understand the potential dangers associated with the oxidizers such as hydrogen peroxide and have completed extensive safety training.

7.0 LESSONS LEARNED ON PREVIOUS ISOTEC PROJECTS

Past experience at similar sites suggests several lessons learned that should be considered during this remediation program.

- **Surfacing** – Subsurface reactions produce gases that migrate vertically. Any vertical permeability pathways or conduits can allow the gas to migrate to ground level and "surface". The gas can transport groundwater and reagent through the conduit as well, therefore liquid can bubble to surface. Conduits can be naturally occurring, i.e. fractures, or man made. Natural fractures are normally observed in clays and dry silts. Man made conduits include abandoned bore holes or probe holes, annular spaces of monitoring wells, monitoring well casings, and injection well annular spaces. All future bore and probe holes should be abandoned with hydrated bentonite to 6 inches below grade and a concrete plug to surface, or pressure grout method. Monitoring wells within 15 feet of an injection point location should have a PVC threaded adapter glued on and a threaded cap with pressure gauge attached during injection. Annular spaces of monitoring wells should be observed during injection for liquid accumulation in the street box or surfacing around the street box. The DPT subcontractor will plug the injection locations using a pressure grout method as the rods are removed.
- **Increasing Groundwater Concentrations** – The ISOTEC process causes contaminant desorption as well as oxidation in the dissolved phase. If sufficient contaminant mass is present in the adsorbed phase or as non-aqueous phase liquid (NAPL), more mass may be transferred to the dissolved phase than can be treated during one injection event. This can result in higher contaminant groundwater concentrations within the pilot test area after injection than before injection. Total contaminant mass will still be reduced. Migration of increased dissolved mass is not expected since it is in disequilibrium with the soil. Therefore, dissolved re-adsorbs to soil before it has time to migrate.
- **Variations in Permeability** – Permeability variations laterally can cause significantly different injection conditions. Pressures, flow rates and injection volumes can vary from well to well. Vertical permeability variations can cause poor distribution of reagent even in a relatively uniform lithology.
- **Estimated Volumes** – The estimated volumes for this remediation program are based on review of applicable data and ISOTEC's past field experience. The actual volume of reagents used will depend upon the injection flow rate, pressure and radial effects, primarily changes in dissolved contaminant concentrations, noted during the program.

FIGURES



LEGEND
Zone A Monitoring Well
Zone B Monitoring Well
Zone C Monitoring Well
Recovery Well
Temporary Piezometer
43,000 Dissolved 1,1-Dichloroethane (EDC) Concentration (ug/L)
Soil Boring
Approximate Area of Conern
ISCO Pilot Test Treatment Area
AOC 1
AOC 2
PROPERTY LINE
EQUILIZATION BASIN
AERATION BASIN
WASTE WATER TREATMENT PLANT
DRYING BEDS
ANOCO BASIN
SANITARY TREATMENT PLANT
FIELD
EDC TANK
EDC TANK
P-47 ND
P-46 ND
P-34 ND
P-35 5
P-33 ND
16
17
ND
D-42
P-45
D-23
P-47 ND
D-34 ND
D-44 ND
P-20 1
RS-2 12
D-5 ND
P-19 31
P-18 ND
TPZ-AOC1-A4 37
TPZ-AOC1-A5 ND
P-8
D-16 ND
P-32 ND
TPZ-AOC1-A3 1,600,000
P-57 600,000
RS-6 170,000
P-56 1,200,000
TPZ-AOC1-A1 410,000
TPZ-AOC1-B1 860,000
TPZ-AOC1-A2 1,800,000
P-14 ND
D-4 ND
P-4 ND
D-10 ND
RD-2 ND
TPZ-AOC1-C1 ND
D-22
D-39
D-41 470,000
P-10
P-31 36
180
RD-3 1,700
42 ND
P-22 1.6
ND
D-2 120
RS-1 170,000
6,000
RD-1 77,000
P-13 400
P-55
P-51
P-50
D-21
30-3
P-36 270,000
D-14 110
D-12 2,700
D-13 4.1
RS-3 200,000
TPZ-AOC2-B1 43,000
TPZ-AOC2-B2 250
P-3 20,000
D-3 ND
D-8
P-24
D-6
D-9
RS-5 390
RS-4
P-23 ND
N
0 100 200
1 INCH = 200 FEET
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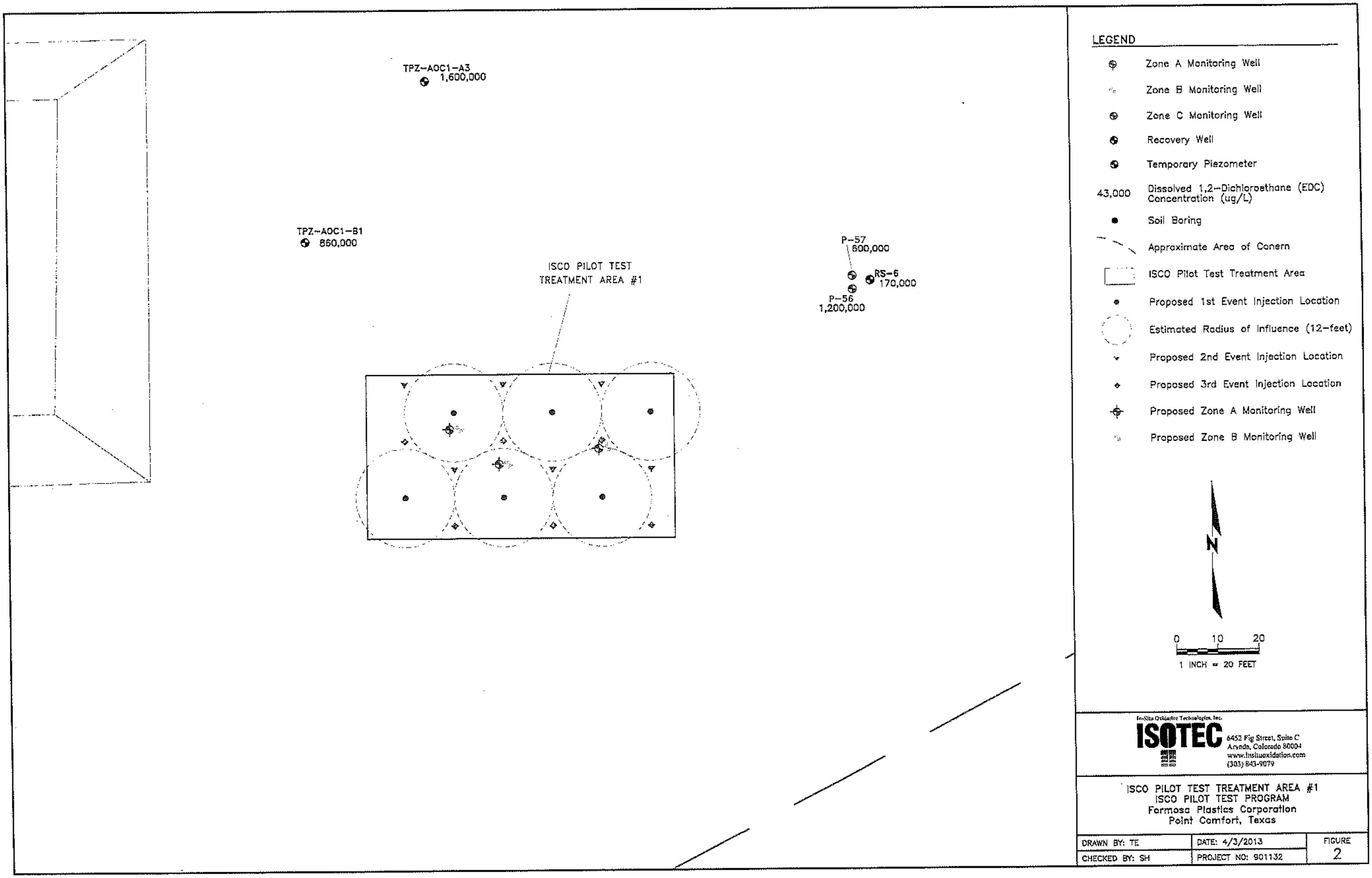
SITE MAP
ISCO PILOT TEST PROGRAM
Formosa Plastics Corporation
Point Comfort, Texas
DRAWN BY: TE
DATE: 4/3/2013
FIGURE 1
CHECKED BY: SH
PROJECT NO: 901132


TPZ-AOC1-A3
1,600,000
TPZ-AOC1-B1
860,000
ISCO PILOT TEST
TREATMENT AREA #1
P-57
600,000
RS-6
170,000
P-56
1,200,000
LEGEND
Zone A Monitoring Well
Zone B Monitoring Well
Zone C Monitoring Well
Recovery Well
Temporary Piezometer
43,000
Dissolved 1,2-Dichloroethane (EDC) Concentration (ug/L)
Soil Boring
Approximate Area of Conern
ISCO Pilot Test Treatment Area
Proposed 1st Event Injection Location
Estimated Radius of Influence (12-feet)
Proposed 2nd Event Injection Location
Proposed 3rd Event Injection Location
Proposed Zone A Monitoring Well
Proposed Zone B Monitoring Well
N
0
10
20
1 INCH = 20 FEET
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ISCO PILOT TEST TREATMENT AREA #1
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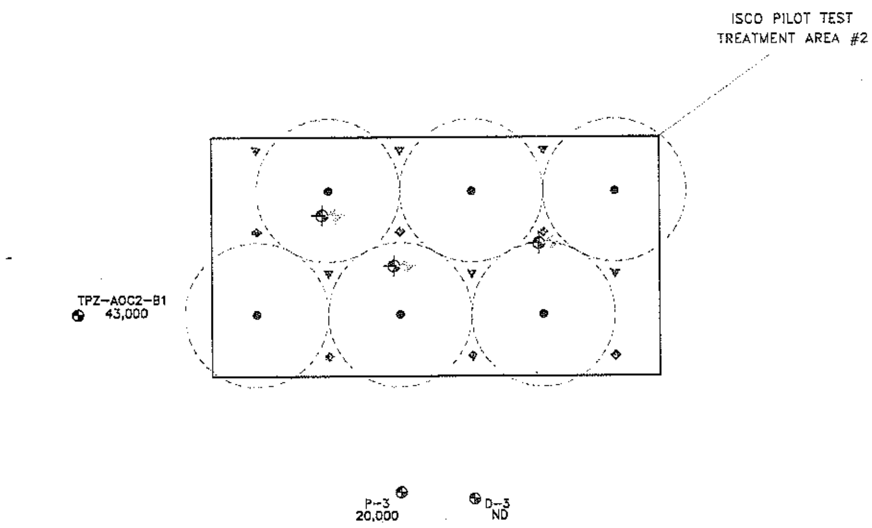
Formosa Plastics Corporation
Point Comfort, Texas
DRAWN BY: TE
DATE: 4/3/2013
CHECKED BY: SH
PROJECT NO: 901132
FIGURE
2



LEGEND

- Zone A Monitoring Well
- Zone B Monitoring Well
- Zone C Monitoring Well
- Recovery Well
- Temporary Piezometer
- 43,000 Dissolved 1,2-Dichloroethane (EDC) Concentration (ug/L)
- Soil Boring
- Approximate Area of Conern
- ISCO Pilot Test Treatment Area
- Proposed 1st Event Injection Location
- Estimated Radius of Influence (12-feet)
- Proposed 2nd Event Injection Location
- Proposed 3rd Event Injection Location
- Proposed Zone A Monitoring Well
- Proposed Zone B Monitoring Well

N

0 10 20

1 INCH = 20 FEET

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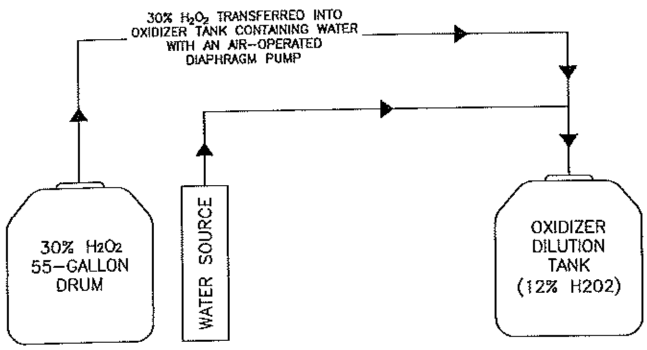
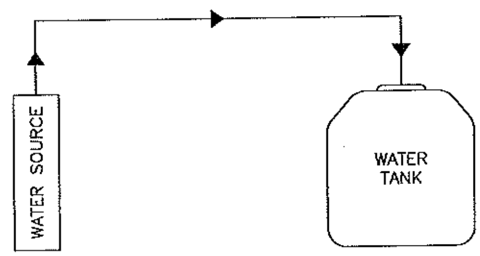
ISCO PILOT TEST TREATMENT AREA #2
ISCO PILOT TEST PROGRAM
Formosa Plastics Corporation
Point Comfort, Texas

DRAWN BY: TE	DATE: 4/3/2013	FIGURE
CHECKED BY: SH	PROJECT NO: 901132	3

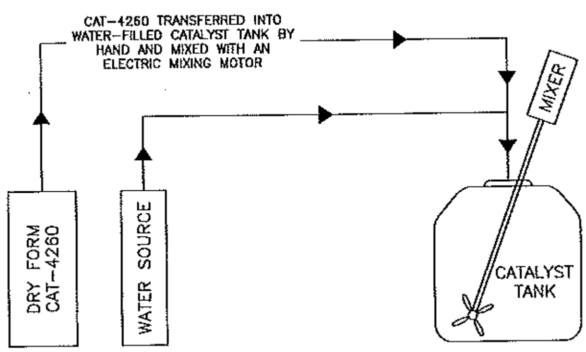
OXIDIZER TANK PROCEDURES



WATER TANK PROCEDURES



CATALYST TANK PROCEDURES



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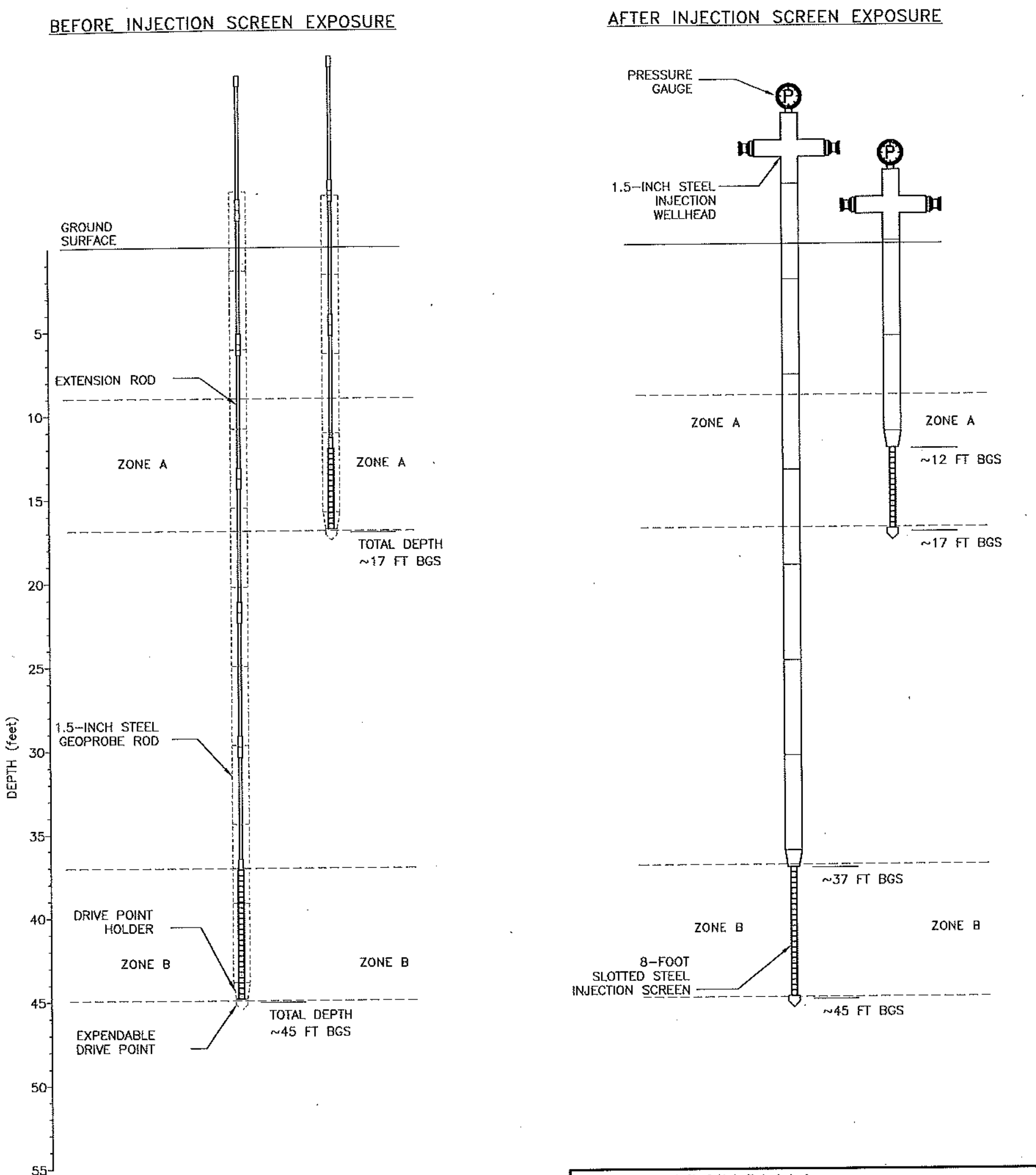
REAGENT MIXING SCHEMATIC
ISCO PILOT TEST PROGRAM
Formosa Plastics Corporation
Point Comfort, Texas

DRAWN BY: KH	DATE: 4/3/2013	FIGURE 4
CHECKED BY: SH	PROJECT NO: 901132	



INJECTION SCREEN INSTALLATION (AREA #1)

1. Probe rod will be advanced to the bottom of Zone A or Zone B by a direct-push subcontractor.
2. A 5-foot or an 8-foot injection screen will be lowered to the bottom of the rod string and held in place with extension rod.
3. The rod string will be extracted 5 or 8 feet to expose the screen across the target saturated treatment interval.
4. Depths are approximate and will be refined on data and sample collection depths.

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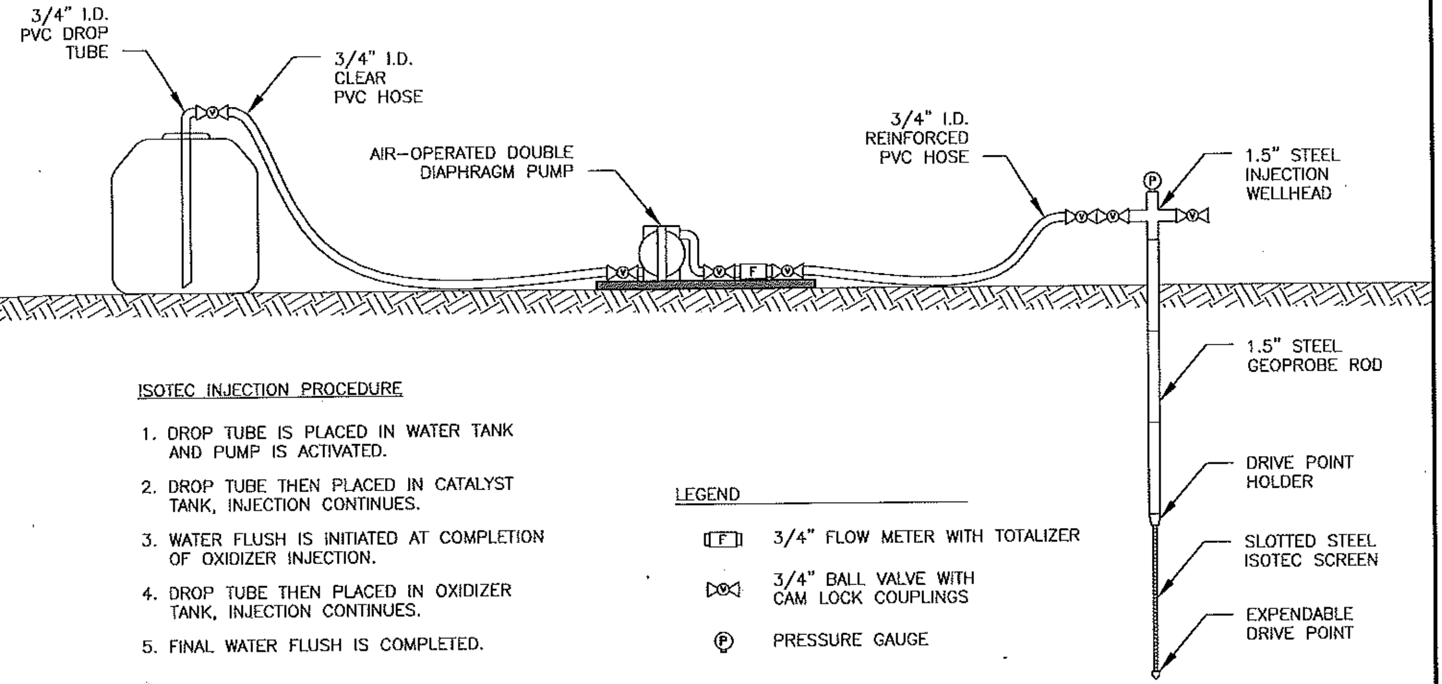
DIRECT-PUSH INJECTION SCREEN SCHEMATIC
ISCO PILOT TEST PROGRAM
Formosa Plastics Corporation
Point Comfort, Texas

DRAWN BY: TE	DATE: 4/4/2013	FIGURE 5
CHECKED BY: SH	PROJECT NO: 901132	

REAGENT INJECTION DIAGRAM



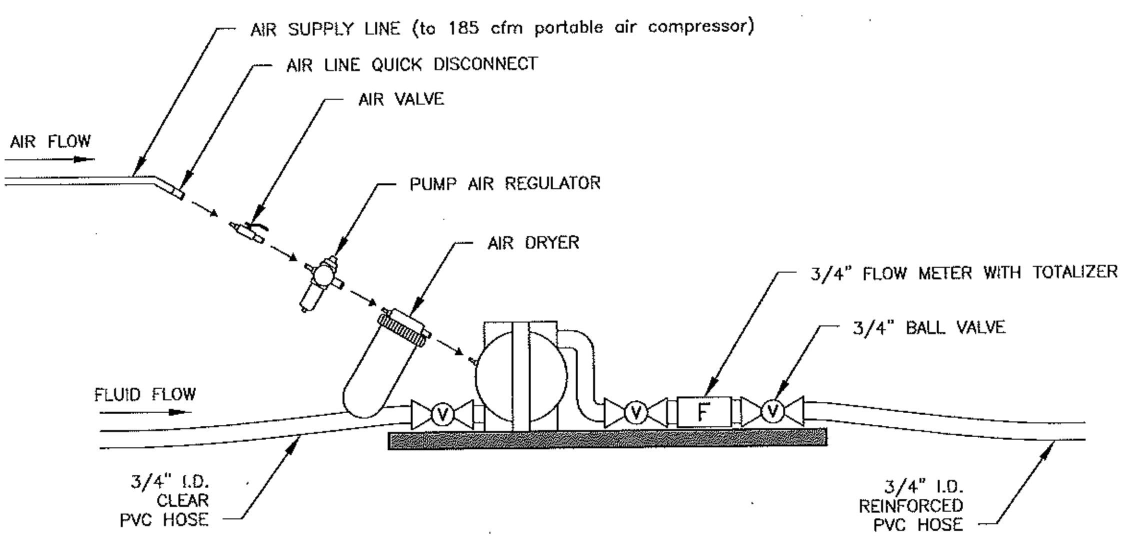
ISOTEC INJECTION PROCEDURE

1. DROP TUBE IS PLACED IN WATER TANK AND PUMP IS ACTIVATED.
2. DROP TUBE THEN PLACED IN CATALYST TANK, INJECTION CONTINUES.
3. WATER FLUSH IS INITIATED AT COMPLETION OF OXIDIZER INJECTION.
4. DROP TUBE THEN PLACED IN OXIDIZER TANK, INJECTION CONTINUES.
5. FINAL WATER FLUSH IS COMPLETED.

LEGEND

F	3/4" FLOW METER WITH TOTALIZER
V	3/4" BALL VALVE WITH CAM LOCK COUPLINGS
P	PRESSURE GAUGE

INJECTION PUMP INSTALLATION



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INJECTION METHOD SCHEMATIC
ISCO PILOT TEST PROGRAM
Formosa Plastics Corporation
Point Comfort, Texas

DRAWN BY: KH	DATE: 3/21/2013	FIGURE
CHECKED BY: SH	PROJECT NO: 901132	6

ATTACHMENT 1

THE ISOTEC PROCESS

THE ISOTEC PROCESS

The ISOTEC process is an in-situ remedial technology that destroys organic contamination using Fenton's reagent-based oxidation chemistry. Fenton's chemistry was first documented by H.J.H. Fenton in 1894. It is characterized by the combination of soluble iron with low concentrations of hydrogen peroxide to produce hydroxyl radicals ($OH^{\bullet}$). These hydroxyl radicals are very powerful and short-lived oxidizers. Similar to the reaction of other oxidizers, the hydroxyl radicals attack the carbon double bonds of the chlorinated hydrocarbon molecule. Under certain conditions reductive species can also be formed by Fenton's chemistry. This gives Fenton's reagent two separate pathways to attack a wide range of contaminants. The summary equation for Fenton's chemistry is shown below.

$$\mathbf{Fe^{+2} + H_2O_2 \rightarrow Fe^{+3} + OH^- + OH^{\bullet}}$$

Where H_2O_2 is hydrogen peroxide, Fe^{+2} is ferrous iron, Fe^{+3} is ferric iron, $OH^{\bullet}$ is hydroxyl free radical and OH^- is hydroxide ion.

Iron is used to catalyze the reaction. Maintaining iron in solution is important for the process to be successful in an in-situ application. To eliminate the necessity of performing the reaction under low pH conditions, as is the case with traditional Fenton's chemistry; complexed iron is used in in-situ applications via the ISOTEC process. The hydrogen peroxide and dissolved iron solutions are injected through a site-specific delivery system providing sufficient distribution to selectively treat the area of concern. Reaction time is very fast, with oxidation capacity of the reagent being used up in a matter of a few days. Hydrogen peroxide breaks down into water and oxygen and the iron catalyst is oxidized and precipitates out of solution. It is important to note that the concentration of hydrogen peroxide will be relatively dilute, generally less than 17%, which eliminates the potential for significant exothermic reactions that are associated with higher concentrations of hydrogen peroxide. Experience with this process using low hydrogen peroxide concentrations and complexed iron has resulted in less than a 25° F temperature increase in field applications.

Fenton-based oxidation processes have been shown to effectively treat a wide range of contaminants including hard-to-treat compounds such as chlorinated solvents, petroleum hydrocarbons, gasoline additives including benzene, toluene, ethylbenzene and xylene (BTEX), and pesticides. Hydroxyl radicals and reductive species generated by the Fenton-based reagent will treat nearly all contaminants with carbon/carbon double bonds and single bonded contaminants with extractable hydrogen.

The stoichiometric relationship between benzene oxidation and hydrogen peroxide consumption can be predicted from the oxidative reaction:

$$\mathbf{C_6H_6 + H_2O_2 \rightarrow 6CO_2 + H_2O + 3H^+}$$

Where C_6H_6 is benzene, H_2O_2 is hydrogen peroxide, CO_2 is carbon dioxide, and H^+ is hydrogen ion. Hydrogen peroxide not consumed in the above reaction will continue to oxidize the groundwater contaminants and will naturally degrade along with the contaminant to oxygen and water.

The ISOTEC process consists of injecting stabilized hydrogen peroxide and complexed iron catalysts into contaminated aquifers or vadose zones. As compared to conventional Fenton's Reagent which requires acidic conditions ($pH \leq 3$) the ISOTEC process is effective at neutral ($pH = 7$) conditions. This is an important consideration in full-scale application since acidifying an aquifer is typically impractical. ISOTEC's oxidation method utilizes a site-specific delivery system(s) designed to treat organic contaminants within an area of concern. ISOTEC oxidants and catalysts generate hydroxyl radicals, which react with the organic contaminants within the subsurface producing innocuous by-products such as carbon dioxide and water (and chloride ions if chlorinated compounds are being treated).

In-Situ Chemical Oxidation of Chlorinated Compounds

The remediation process for treating chlorinated compounds in the subsurface is straight forward from a chemical standpoint but complicated in practice. The major oxidants available for in-situ application are:

- Fenton's Reagent,
- Modified Fenton's Reagent,
- Ozone,
- Permanganate,
- Persulfate, and
- Catalyzed persulfate.

These oxidants have varying oxidation potentials, or "oxidation strength". In simple terms, the oxidant contacts with the solvent and the solvent molecule is oxidized, gives up an electron, and forms new compounds from the original elements. For example, TCE oxidizes into carbon dioxide and chlorine ions. There can be short lived intermediaries, but they do not persist long enough to measure.

The remediation process is very simple for compounds in the dissolved phase. For instance, a beaker filled with a 5,000 µg/L solution of TCE in water can be oxidized by adding the appropriate mass of any of the above oxidants to non-detectable levels in a very short period, from hours to several days. Because of the varying oxidation potentials, the same is not true for a solution of TCA, only the Fenton's based oxidants and ozone will treat the dissolved TCA mass.

When treating in-situ however, many more factors are hindering the chemical oxidation process. The main complicating factors are:

- Distribution of contaminant,
- Distribution of oxidant,
- Presence of other compounds that consume oxidant,
- Contaminant phases, and

- Aqueous contact of contaminant and oxidant.

In short, it is more difficult to contact a molecule of oxidant with a molecule of contaminant, in-situ, since neither is evenly mixed in a beaker. These differences are not apparent in most laboratory studies because of the way the studies are conducted. Studies are often completed using only groundwater which eliminates almost all of the hindering factors. Even studies using soil and groundwater are generally set-up with excess groundwater to form slurry. This set-up not only mixes the contaminant and oxidant but also preferentially changes the NAPL and adsorbed contaminant phases into the dissolved phase, where they are easily contacted by the oxidant.

Distribution of Contaminant

Unlike the beaker example, contaminant mass in the subsurface is distributed heterogeneously and in unknown patterns and within varying lithologies. Although dissolved contaminant concentrations indicate the approximate location of a source zone, they cannot pinpoint the mass either vertically or laterally. Other investigative methods can help define the mass distribution. But ultimately, due to the migration patterns of the LNAPL, the exact area requiring treatment can be elusive. This causes the in-situ treatment process to be inclusive of large areas in order to be successful.

Distribution of Oxidant

Since the precise area of contaminant mass can only be generally defined, the oxidant must be uniformly delivered across complete target areas in order to be successful. If areas of mass are missed, either vertically or laterally, the plume persists and the remediation process stalls. For the short lived oxidants, Fenton's, modified Fenton's, ozone, and catalyzed persulfate, this step becomes very critical because the oxidant does not travel or disburse once injected. Therefore, these must be delivered uniformly across the treatment area.

The persistent oxidants, permanganate and persulfate, can move with groundwater and disperse by concentration gradient over time. Therefore, precise distribution across the plume is not as critical as with the short-lived oxidants. The concentration of the oxidant, however, does decrease during this process as it is consumed and diluted within groundwater.

Other Compounds that Consume Oxidant

Soil matrices are comprised of a mixture of materials, some of which can produce an oxidant demand. The foremost of these is organic carbon. Organic carbon is, for the most part, a solid. Oxidants are non-selective; they will address any organic compound with which they come in contact. In-situ, however, they are selective about the phase that the compound is in. An oxidant will address dissolved mass quickly and a solid more slowly as the oxidation process is an aqueous one. Therefore, organic carbon impacts the remediation process over time as opposed to the short term. This hinders the effectiveness of the persistent oxidants more than the short lived oxidants.

Aqueous Contact

The overwhelming portion of the oxidation process occurs in the aqueous phase. Contaminant dissolved in water contacts oxidant dissolved in water and the oxidation reactions occur. This is, for all practical purposes, an instantaneous process. The same is not true for contaminant mass that is present adsorbed to soil or found as NAPL. These two phases must be moved into the aqueous phase in order to be treated in a practical manner.

Mass Phase Changes

The only oxidant that actively transfers mass into the dissolved phase is modified Fenton's with neutral pH catalyst. The modified Fenton's process greatly disturbs the mass equilibrium between the phases. The hydroxyl radical oxidizes contamination in the dissolved phase while the superoxide radical desorbs mass from the adsorbed phase by interfering with the electrical (molecular) forces that cause molecules of contaminant to "stick" to grains of soil and organic carbon. In addition to these chemical processes, the reaction produces oxygen gas. As the peroxide decomposes it generates oxygen. This gas is produced within the individual pore spaces where the two reagents are mixed. As the gas bubbles are generated and then migrate vertically up through soil pores, a physical action occurs that mixes groundwater, disturbs soil "fines" (increasing turbidity) and dislodges residual NAPL. Mass is transferred from the adsorbed and NAPL phases into the dissolved phase through this physical agitation. Mass is also transferred from the NAPL phase to the adsorbed phase as the NAPL is mixed within the pore space and contacts more soil surface area.

These chemical and physical processes upset the phase equilibrium and can be observed as temporary increases in dissolved concentrations, especially early in the treatment program when the total mass is still at levels near the original mass. However, given that such a small percentage of the total mass exists in the dissolved phase, even an order of magnitude increase in the dissolved phase mass is still only a fraction of the total mass. As the total mass decreases with multiple injections, the post-injection increases in dissolved concentrations also decrease. Post-injection dissolved concentrations will remain elevated and out of equilibrium with the total mass even as the total mass approaches minimal levels. Only time will allow the dissolved mass and total mass to re-equilibrate through dilution, dispersion, re-adsorption and degradation. This time period varies depending on specific site conditions but has been observed to take from months up to quarters.

Other oxidants; permanganate, persulfate, catalyzed persulfate and ozone, can cause some mass transfer into the dissolved phase. However, this is due to the limited physical agitation caused by the injection process. Even injecting a gas, as is done to deliver ozone, does not cause a significant mass transfer due to the preferential pathways created during injection. These pathways limit the extent to which the gas bubbles move through individual pore spaces since the gas travels along the path of least resistance and is not generated in individual pore spaces.

For the short lived oxidizers, this means that the oxidant is injected and treatment occurs almost instantly. The oxidant is consumed and the treatment process is complete within several days if not hours. The modified Fenton's process actively transfers mass from the adsorbed and NAPL phases in the aqueous phase where oxidation can occur. This process allows for significant mass destruction in a short period of time. Ozone and catalyzed persulfate do not actively transfer mass and therefore, treat primarily the dissolved mass present at the time of injection and do not address the larger mass present in the soil matrix.

The longer lasting oxidants, permanganate and persulfate, are injected and the dissolved mass is treated almost instantly. However, the oxidant can persist in the subsurface, if not immediately consumed, for weeks or months and continue to treat contaminant mass that transfers into the aqueous phase from the adsorbed or NAPL phases. Since these two oxidants do not actively desorb mass the treatment process is slow, relying on diffusion gradients between "clean" groundwater and the remaining contaminant mass to transfer mass into the dissolved phase. Anecdotal observations lead to this conclusion. If the oxidants did actively treat the adsorbed and NAPL components of the mass, why would they persist in the subsurface instead of being consumed by the remaining contaminant mass? Observations have shown repeatedly that after injection the dissolved contaminant concentration decreases drastically, often to non-detectable levels almost immediately. Yet, after the oxidant is depleted, or diluted, over several months the dissolved concentrations return to near baseline concentrations.

Oxidant Applications

The different oxidants can be useful in various applications. They can all be used to limit the down-gradient progress of a dissolved plume. In this application the dissolved component of the contaminant mass can be reduced at the property boundary to limit down-gradient migration of the additional dissolved mass. This will not significantly reduce the down-gradient total mass that is already present, but may temporarily reduce the dissolved concentrations.

If mass reduction is the goal then phase changes must occur. Modified Fenton's is the only oxidant that actively transfers mass from the adsorbed and NAPL phases into the dissolved phase. The majority of the total mass, even in low concentration plumes, is found in the adsorbed and/or NAPL phases. If these are not addressed the groundwater plume will rebound to near original concentrations following consumption of the oxidant.

APPENDIX B

Pilot-Scale Treatability Testing Work Plan - DPE

GAINCO
ENVIRONMENTAL REMEDIATION

June 14, 2013

Mr. Matt Wickham, PG
Pastor, Behling & Wheeler, LLC
620 E. Airline
Victoria, TX 77901

Re: Phase II Pilot Testing - Work Plan
Formosa Plant
Point Comfort, TX

Dear Mr. Wickham,

This letter transmits the Work Plan (WP) for Phase II Pilot Testing at the above referenced site. In October 2012, Phase I Pilot Testing consisting of soil vapor extraction (SVE), aquifer pump testing, and dual-phase extraction (DPE) was conducted at the project site as a preliminary indicative mass removal pilot test. Three primary parameters were evaluated to determine the relative effectiveness of the three remedial techniques tested: (1) groundwater extraction rate, (2) radius of influence (ROI), and (3) mass removal.

Comparing the aquifer pump test to the DPE test, the average groundwater recovery rate was 0.57 gpm for conventional recovery and 0.65 gpm for DPE (a 14% increase). The normalized ROI for SVE and DPE testing was 7.5 ft. and 11.5 ft., respectively, indicating a 53% increase in ROI for DPE relative to conventional SVE. Finally, the clearest indicator of remediation effectiveness is the extraction rate of hydrocarbons from the affected media. Because groundwater recovery is not in and of itself a significant hydrocarbon mass removal method, it was not evaluated with respect to hydrocarbon mass removal. Based on the SVE and DPE Phase I data, the extraction rate was lowest when only SVE was employed (0.07 lb/hr) and was significantly higher when the system was operated in high vacuum DPE mode (0.83 lb/hr – an order of magnitude increase in hydrocarbon mass removal).

The principal contaminant at the site is Ethylene dichloride (EDC). The volatility of EDC makes it a viable candidate for remediation via DPE. Although, the low permeability soil reduces the overall influence of vapor phase recovery, DPE remains a viable remedial technique for this site due to the high vapor phase mass removal recorded during the pilot test. Based on the Phase I data and evaluation, Phase II DPE testing is proposed for this site.

Based on Phase I Pilot Test analysis and supplementary information provided, Phase II Pilot Testing will consist of conducting two tests (two different areas of the site) extracting from two wells simultaneously for each test. The two test areas, shown on Figure 1, were chosen based on criteria including the degree of EDC impact, proposed remedial goals, representativeness of the geologic profiles, and access to testing equipment and crew. Prior to testing, four extraction wells and eight monitor points will be installed (each test area will have two extraction wells and four monitor points). The scope presented below represents one test area. The scope will be repeated for the second test area.

Test Well and Monitoring Point Installation (Scope to be Repeated for each Test Area)

Prior to conducting the Phase II Pilot Test, two temporary 2-inch diameter extraction wells will be installed in each test area. In addition to the extraction wells, each area will also include the installation of four 2-inch diameter monitor points to monitor groundwater level and in-situ vacuum prior to and during the test. Prior to arrival, PBW personnel shall preliminarily locate and obtain clearance from plant personnel for the test well locations.

Based on information provided, the thin upper groundwater zone extends from approximately 12-14 feet (ft) below ground surface (bgs), a thickness of approximately 2 ft. It is anticipated that the pilot test wells will extend approximately 15 to 20 ft bgs in order to fully penetrate the uppermost groundwater-bearing zone. The screened interval for the extraction wells is preliminarily estimated to be from 10-20 ft bgs and will be confirmed by collaboration between the GAINCO geologist and PBW project manager prior to setting to ensure the screened interval includes the permeable target zone. For the monitor points, the screened interval will also extend from 10-20 ft bgs such that each point can be used to monitor groundwater level or in-situ vacuum, as determined by the test crew and the PBW project manager.

The test wells will be temporary and will be comprised of PVC casing and screen, sand pack filter, and bentonite/grout seal (a seal of approximately 8 feet will be in place to ensure a positive seal against the vacuum induced during the test). The wells will be installed such that the top of the PVC casing will be approximately 3 feet above ground. No concrete pads will be installed since the wells will be plugged upon completion of testing. Soil cores will be collected continuously during well installation. Soil samples will be collected for volatile organic hydrocarbon (VOC) analyses every 5 feet in the extraction well borings. The test wells will be properly plugged and abandoned after completion of the pilot testing.

Background Data Collection (Scope to be Conducted Concurrently is each Test Area)

Background data will be collected at each test area simultaneously for a period of approximately 24 hours and at a designated time prior to the testing. Background data will consist of recording groundwater levels and barometric pressure to establish correlations, if any, between barometric pressure and water levels and to evaluate potential tidal affects. These correlations may be used to adjust water level data collected during the test.

The data will be collected by setting a data logging water level transducer in an existing monitor well in each test area. In addition, a second probe will be left on site to monitor the barometric pressure.

Phase II Pilot Testing (Scope to be Repeated for each Test Area)

The purpose of the pilot test is gather sufficient data to facilitate the potential design of a DPE remediation system for the site. The test apparatus will consist of a liquid ring pump connected to a 1-inch diameter PVC pipe (stinger) inserted into each of the two extraction wells to a depth just below the target thin groundwater zone. The general pilot test arrangement is shown on Figure 2. By sealing the annular area with the stinger below the groundwater level, high vacuum DPE will be conducted.

The pilot test will be conducted over 3 2-days in each area. Testing will be initiated by a DPE step test, whereby for a period of approximately 6-8 hours, the vacuum will be increased in step fashion. Once the maximum extraction vacuum is reached, the DPE test will be conducted until approximately 48 hours after initiating the step test.

The activities conducted during the testing will generally consist of the following.

- Mobilize Vacuum Pump (liquid ring pump), generator, fuel, data loggers, and miscellaneous equipment.
- Based on previous testing at the site, the hydrocarbon loading of the extracted soil vapor may not exceed allowable emission limits without controls; however, in order to maintain compliance and because the Phase II test areas may differ from the Phase I test area, granular activated carbon (GAC) will be utilized for vapor treatment.
- Install a data logging transducer in a nearby well (outside the expected influence of the DPE testing) to monitor background water level data during the test and use a second logging transducer to record barometric pressure during the test. A single barometric probe will be used for both sites, but for background water level data, one probe for each area will be used.
- Conduct the DPE Step Test to determine the optimal conditions in terms of vacuum and flow. It is anticipated this test will take less than 8 hours. Previous data indicated an extraction rate of approximately 20 scfm at a vacuum of 15-19 inches of mercury (in. Hg.). By stepping the vacuum up from the minimum required to recover vapors to the maximum vacuum, the in-situ vacuum response and hydrocarbon loading can be evaluated over a range of operating conditions.
- Conduct the DPE Test at the final vacuum for the duration of the testing period. It is anticipated this test will take approximately 36-40 hours.
- Record the vacuum at the LRP, extraction wellhead, monitor points, and nearby monitor wells.
- The following parameters will be recorded during the test:
    - Vacuum at the LRP, DPE wells, monitor points, and nearby monitor wells.
    - Extracted soil vapor concentration using a photoionization detector (PID), flow rate, vacuum, and temperature at discrete time increments at a designated point in the vacuum recovery piping prior to GAC treatment to evaluate hydrocarbon extraction rates.
    - Vapor concentrations (using a PID) of soil vapor after GAC treatment to verify emission compliance.
    - Exhaust air flow, exhaust temperature, and exhaust pressure from the GAC.
    - Groundwater levels in designated monitor points and/or nearby monitor wells to evaluate the aquifer response to DPE over time.
- One soil vapor sample will be collected at the beginning of each DPE Step for VOC analysis (to include EDC). One sample will be collected at the beginning of the high vacuum DPE test and every 5 hours thereafter for VOC analysis to confirm the hydrocarbon recovery over time.

Waste Management

It is our understanding that the recovered groundwater at the site is treated as a listed hazardous waste based on plant protocol. Therefore, the water will be contained in tanks provided by plant personnel pending final disposition by Formosa. Recovered soil vapors will be treated with GAC. Characterization and final disposition of recovered groundwater, spent GAC, and drill cuttings (if any) is not part of this WP.

Documentation

A Pilot Test Report will be prepared presenting data collected during the test at each area. The report will include tabular and graphical presentations of vapor phase hydrocarbon extraction rates and cumulative recovery, subsurface vacuums at the designated monitor points, radial influence evaluation for subsurface vacuum, groundwater levels/drawdowns at designated points, groundwater recovery rates, and effective hydraulic conductivity and transmissivity based on the DPE conditions.

Schedule

Well installation will be conducted in two days. The pilot testing activities will be conducted in two consecutive days at each area (total of four days).

Sincerely,

Tom J Weber

Tom J Weber, PE
Gainco, Inc.

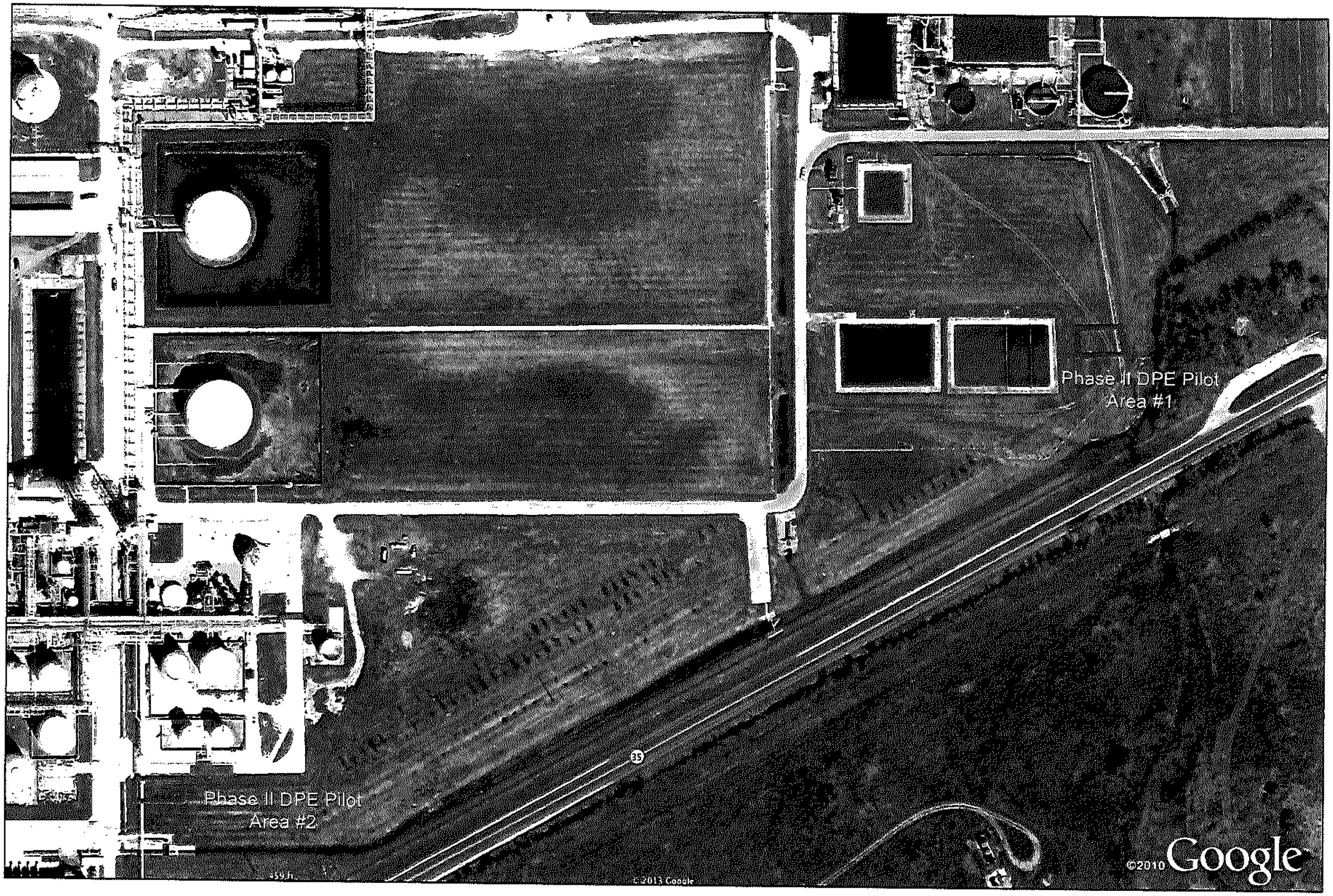

Figure 1: Pilot Testing Areas

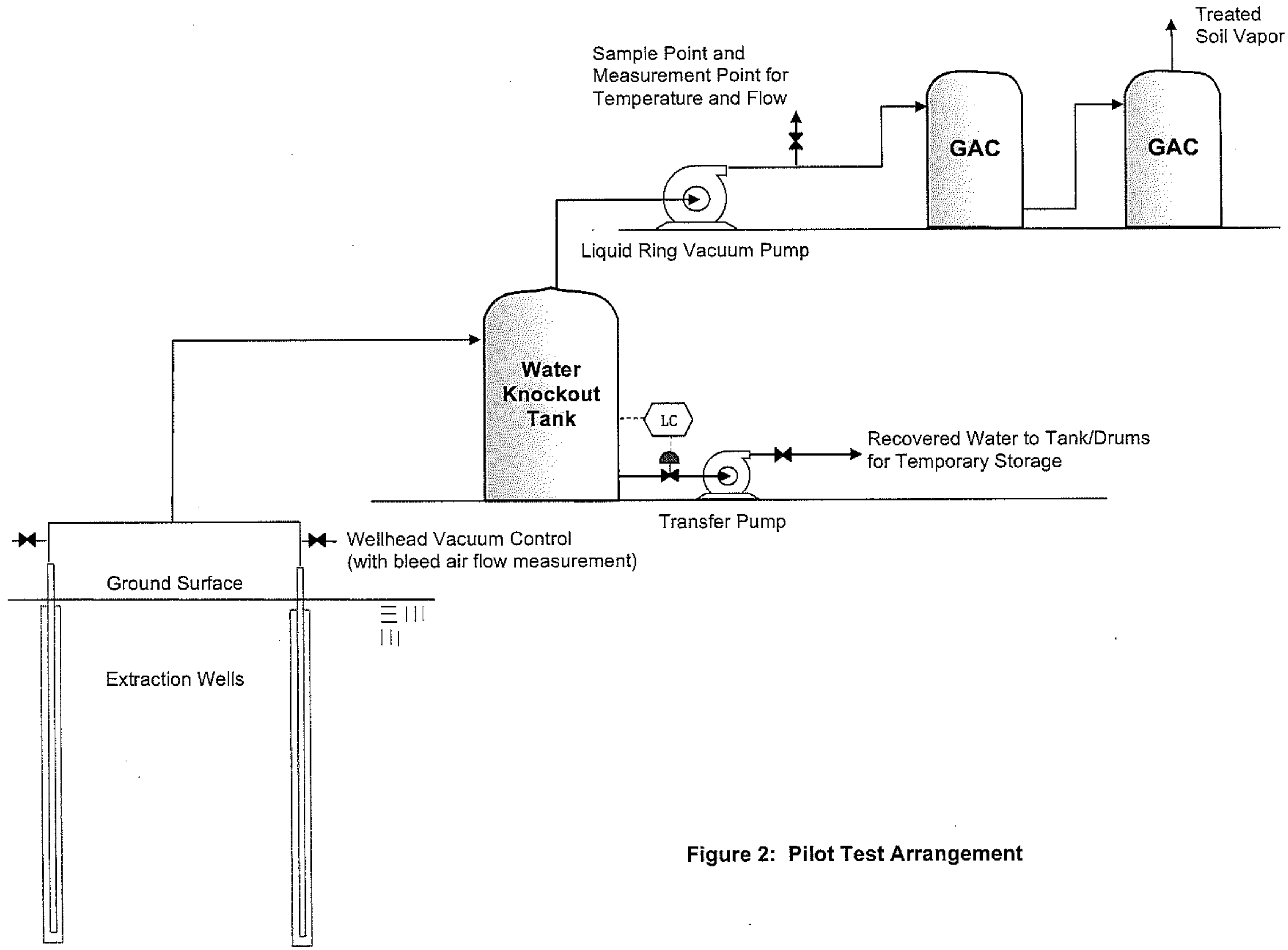

Figure 2: Pilot Test Arrangement

Formosa Plastics

Formosa Plastics Corporation, Texas
201 Formosa Drive • P.O. Box 700
Point Comfort, TX 77978
Telephone: 361-987-7000

October 6, 2016

Via e-mail and Certified Mail:
7015 3430 0001 0536 3641

Ms. Nancy Fagan
Project Coordinator - 6PD-O
U.S. Environmental Protection Agency
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

RE: Termination Request
RCRA Docket No. VI-001(h)-90-H
Section 3008(h) Administrative Order on Consent, as Amended
EPA I.D. No. TXT490011293
Solid Waste Registration No. 31945

Dear Ms. Fagan:

As you are aware, the Post Closure Order (PCO) for Formosa Plastics Corporation, Texas (FPC-TX) was signed on October 5, 2016 by Commissioner Shaw and became effective upon signing.

Now that the PCO has been issued, we believe that FPC-TX has satisfied the requirement of Section IX, Item N.1 of Amendment No. 2 to the 3008(h) Order. At this time FPC-TX is requesting written confirmation of such termination from the EPA.

If you have any questions about this report please contact Matt Brogger at (361) 987-7468 or by e-mail at mattb@ftpc.fpcusa.com.

Sincerely,

Rick Crabtree
Vice President/General Manager
Formosa Plastics Corporation, Texas

cc: Ms. Susan Clewis — Certified Mail: 7015 3430 0001 0536 3658
TCEQ, Region 14
6300 Ocean Drive, Suite 1200
Corpus Christi, TX 78412

Ms. Maureen Hatfield, (MC-127) — Certified Mail: 7015 3430 0001 0536 3665
Texas Commission on Environmental Quality
P.O. Box 13087
Austin, TX 78711-3087

Formosa Plastics

Formosa Plastics Corporation, Texas
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Point Comfort, TX 77978
Telephone: 361-987-7000

RECEIVED
SEP 28 2016

September 23, 2016

Via e-mail and Certified Mail:
7015 3430 0001 0536 3375

Ms. Nancy Fagan
Project Coordinator
6PD-O
U.S. Environmental Protection Agency
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

RE: Corrective Measures Implementation Progress Report
RCRA Docket No. VI-001(h)-90-H
Section 3008(h) Administrative Order on Consent, as Amended
EPA I.D. No. TXT490011293
Solid Waste Registration No. 31945

Dear Ms. Fagan:

As per Section V, Task XIV, of the Corrective Action Plan that was amended by Amendment No. 2 (effective on June 12, 2012) to the RCRA Section 3008(h) Order issued in 1991, FPC-TX is submitting its bi-monthly progress report for Corrective Measure Implementation (CMI) under the terms of the amended Order. We are continuing to use a progress report format that we have used for recent years for reports submitted under the Corrective Action Plan that was issued as Exhibit 1 to the 1991 Order. This report covers the time period between the date of the last progress report (July 25, 2016) and today's date. We understand that EPA wishes us to maintain the prior schedule and due dates under the amended Order, which would mean that these progress reports are due on the 25th of every other month.

Meetings and Conference Calls:

- A conference call was held on August 15, 2016 between EPA, Tetra Tech and FPC-TX to discuss the status of the Post Closure Order, the Final Corrective Measures Implementation Report and Schedule and the Final Performance Monitoring Plan.

CMI Activities at FPC-TX in August 2016 and September 2016:

- FPC-TX submitted the Final Corrective Measures Implementation Report and Schedule to EPA on August 26, 2016. Additionally, a 45-day extension was requested on August 26, 2016 for the Final Performance Monitoring Plan. EPA granted the extension request in a letter dated September 7, 2016. The deadline for the Final Performance Monitoring Plan is now October 10, 2016.

Planned CMI activities for the next reporting period:

- Submit the Final Performance Monitoring Plan.

If you have any questions about this report please contact Matt Brogger at (361) 987-7468 or by e-mail at mattb@ftpc.fpcusa.com.

Sincerely,

Rick Crabtree
Vice President/General Manager
Formosa Plastics Corporation, Texas

cc: Ms. Susan Clewis — Certified Mail: 7015 3430 0001 0536 3382
TCEQ, Region 14
6300 Ocean Drive, Suite 1200
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Ms. Karen F. Scott, P.G. — Certified Mail: 7015 3430 0001 0536 3399
TCEQ
I&HW Permits Section
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Ms. Merrilee Hupp, (MC-169) — Certified Mail: 7015 3430 0001 0536 3405
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Formosa Plastics

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July 25, 2016

Via e-mail and Certified Mail:
7015 0640 0006 2456 8347

Ms. Nancy Fagan
Project Coordinator
6PD-O
U.S. Environmental Protection Agency
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

RE: Corrective Measures Implementation Progress Report
RCRA Docket No. VI-001(h)-90-H
Section 3008(h) Administrative Order on Consent, as Amended
EPA I.D. No. TXT490011293
Solid Waste Registration No. 31945

Dear Ms. Fagan:

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Meetings and Conference Calls:

- None.

CMI Activities at FPC-TX in June 2016 and July 2016:

- None.

Planned CMI activities for the next reporting period:

- Address any comments to the Draft CMI Report and prepare the final report.

If you have any questions about this report please contact Matt Brogger at (361) 987-7468 or by e-mail at mattb@ftpc.fpcusa.com.

Sincerely,

Rick Crabtree
Vice President/General Manager
Formosa Plastics Corporation, Texas

cc: Ms. Susan Clewis — Certified Mail: 7015 0640 0006 2456 8354
TCEQ, Region 14
6300 Ocean Drive, Suite 1200
Corpus Christi, TX 78412

Ms. Karen F. Scott, P.G. — Certified Mail: 7015 0640 0006 2456 8361
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P.O. Box 13087
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Ms. Merrilee Hupp, (MC-169) — Certified Mail: 7015 0640 0006 2456 8378
TCEQ
P.O. Box 13087
Austin, TX 78711-3087

Formosa Plastics

Formosa Plastics Corporation, Texas
201 Formosa Drive • P.O. Box 700
Point Comfort, TX 77978
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June 17, 2016

Certified Mail:
7015 0640 0006 2456 8309

Ms. Nancy Fagan
Project Manager
6PD-O
U. S. Environmental Protection Agency
1445 Ross Avenue
Dallas, TX 75202-2733

RE: RCRA Docket No. VI-001-(h)-90-H
3008 (h) Administrative Order on Consent
Interim Measures, 1st Quarter 2016 Report

Dear Ms. Fagan:

Please find enclosed your electronic copy of the First Quarter 2016 Interim Measures Groundwater Monitoring Report prepared by Tetra Tech.

Should you require additional information or assistance please contact Matt Brogger at (361) 987-7468 or by e-mail at mattb@ftpc.fpcusa.com.

Sincerely,

Rick Crabtree
Vice President/General Manager
Formosa Plastics Corporation, Texas

Enclosures

cc:	Ms. Merrilee Hupp, (MC-169) TCEQ P.O. Box 13087 Austin, TX 78711-3087	Certified Mail: 7015 0640 0006 2456 8316
	Ms. Susan Clewis TCEQ Region 14 NRC Building, Suite 1200 6300 Ocean Drive, Unit 5839 Corpus Christi, Texas 78412-5839	Certified Mail: 7015 0640 0006 2456 8323
	Ms. Maureen Hatfield, (MC-127) TCEQ P.O. Box 13087 Austin, TX 78711-3087	Certified Mail: 7015 0640 0006 2456 8330

Formosa Plastics

Formosa Plastics Corporation, Texas
201 Formosa Drive • P.O. Box 700
Point Comfort, TX 77978
Telephone: 361-987-7000

May 25, 2016

Via e-mail and Certified Mail:
7015 0640 0006 2456 7906

Ms. Nancy Fagan
Project Coordinator
6PD-O
U.S. Environmental Protection Agency
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

RE: Corrective Measures Implementation Progress Report
RCRA Docket No. VI-001(h)-90-H
Section 3008(h) Administrative Order on Consent, as Amended
EPA I.D. No. TXT490011293
Solid Waste Registration No. 31945

Dear Ms. Fagan:

As per Section V, Task XIV, of the Corrective Action Plan that was amended by Amendment No. 2 (effective on June 12, 2012) to the RCRA Section 3008(h) Order issued in 1991, FPC-TX is submitting its bi-monthly progress report for Corrective Measure Implementation (CMI) under the terms of the amended Order. We are continuing to use a progress report format that we have used for recent years for reports submitted under the Corrective Action Plan that was issued as Exhibit 1 to the 1991 Order. This report covers the time period between the date of the last progress report (March 24, 2016) and today's date. We understand that EPA wishes us to maintain the prior schedule and due dates under the amended Order, which would mean that these progress reports are due on the 25th of every other month.

Meetings and Conference Calls:

- A conference call between, EPA, FPC-TX and Tetra Tech was held to discuss the content of the March 15, 2016 EPA letter to Formosa regarding groundwater monitoring at FPC-TX. The results of that conference call were summarized in a letter from Formosa to EPA dated April 14, 2016.

CMI Activities at FPC-TX in February 2016 and March 2016:

- Formosa submitted the Draft CMI Report to EPA on April 4, 2016.

Planned CMI activities for the next reporting period:

- Address any comments to the Draft CMI Report and prepare the final report.

If you have any questions about this report please contact Matt Brogger at (361) 987-7468 or by e-mail at mattb@ftpc.fpcusa.com.

Sincerely,

Rick Crabtree
Vice President/General Manager
Formosa Plastics Corporation, Texas

cc: Ms. Susan Clewis
TCEQ, Region 14
6300 Ocean Drive, Suite 1200
Corpus Christi, TX 78412

Certified Mail: 7015 0640 0006 2456 7913

Ms. Karen F. Scott, P.G.
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Ms. Merrilee Hupp, (MC-169)
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Formosa Plastics

Formosa Plastics Corporation, Texas
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April 14, 2016

Via e-mail and Certified Mail:
7015 0640 0006 2456 9733

Ms. Nancy Fagan
Project Coordinator
6PD-O
U. S. Environmental Protection Agency
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

RE: Response to the March 15, 2016 Letter from EPA for Groundwater Monitoring Reports and the Performance Monitoring Plan
RCRA Docket No. VI-001(h)-90-H
3008(h) Administrative Order on Consent
EPA I. D. No. TXT490011293
Solid Waste Registration No. 31945

Dear Ms. Fagan:

FPC-TX is in receipt of your letter dated March 15, 2016 in which you requested modifications to the data collection and presentation of the quarterly groundwater monitoring reports, and installation of a new groundwater monitoring well and new groundwater recovery well. FPC-TX and EPA discussed EPA's suggestions via conference call on April 12, 2016. FPC-TX has considered the suggestions provided in the letter and, as requested, has prepared this letter within 30 days which includes a schedule for implementation.

Per EPA's suggestion, FPC-TX reviewed different techniques for identifying DNAPL described in the ITRC guidance, "Integrated DNAPL Site Characterization and Tools Section" and has determined that for now it is best to continue using the current techniques being employed in the quarterly sampling events. It appears that the hydrophobic covers or dyes used to detect DNAPL are geared more for open bore holes or investigative soil samples, but not necessarily for completed monitoring wells. Following TCEQ's issuance of the Post-Closure Order (PCO), FPC-TX will begin implementing additional site investigations in accordance with TRRP. If during an investigation phase of the PCO it is prudent to use the covers or dyes, FPC-TX will employ them at that time.

You requested that color coded PCLE maps be included in the quarterly reports to depict concentrations for 1, 2-dichoroethane and vinyl chloride. We anticipate that this request can be implemented with the second quarter 2016 Groundwater Monitoring Report.

EPA directed FPC-TX to prepare a schedule for installation of a new Zone C monitoring well, previously identified in the Draft Performance Monitoring Plan as monitoring well D-49. As we discussed, FPC-TX anticipates an effective date for the PCO of June 30, 2016 or earlier. If there are no delays with issuance of the PCO, FPC-TX anticipates that monitoring well D-49 will be installed in the 1st Quarter 2017 as part of the Affected Property Assessment based on the schedule included in Table VIII of the PCO. If issuance of the PCO is delayed past June 30, 2016, FPC-TX will reevaluate the schedule for installation of D-49 and adjust it accordingly. We also anticipate that recovery well RD-3 will be redeveloped at this time while the driller is onsite and available.

Lastly, you requested a schedule for the installation of a new recovery well in the lower Zone B near D-11. One of the requirements of the PCO is for FPC-TX to install a recovery well in Zone C within 180 days of the effective date. At this time we would propose to defer installation of the suggested lower Zone B well pending evaluation of the effectiveness of the planned Zone C recovery well, and preparation of the Response Action Plan (RAP) as required by the PCO. Following completion of the APAR, FPC-TX will be evaluating additional recovery wells, as well as other possible treatment approaches and, in accordance with the PCO and TRRP, providing our proposed approach to TCEQ in the RAP. If appropriate, a new Zone B recovery well will be included in the RAP.

If you have any questions about this report, please contact Matt Brogger at (361) 987- 7468 or by e-mail at mattb@ftpc.fpcusa.com.

Sincerely

Rick Crabtree
Vice President/General Manager
Formosa Plastics Corporation, Texas

cc: Ms. Maureen Hatfield, (MC-127) Certified Mail: 7015 0640 0006 2456 9740
TCEQ
P.O. Box 13087
Austin, TX 78711-3087

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS, TX 75202-2733

March 15, 2016

Mr. Rick Crabtree and Mr. Matt Brogger
Formosa Plastics Corporation, Texas
P.O. Box 700
Point Comfort, Texas 77978

RE: Groundwater Monitoring Reporting and the March 28, 2014 Performance Monitoring Plan (PMP) from the Administrative Order on Consent (AOC) Docket #VI – 001(h)-90-H

Dear Mr. Crabtree and Mr. Brogger,

The purpose of this letter is to address issues with groundwater monitoring reporting and the PMP submitted March 28, 2014.

In reviewing the groundwater monitoring quarterly reports of 2015, the EPA has made observations and is requesting the following improvements to data evaluation and presentation for future groundwater monitoring reports, and to the groundwater monitoring well design from the PMP:

First, is a needed change to the method used to measure dense non-aqueous phase liquids (DNAPL). There are new techniques to employ to obtain information about whether DNAPL is present in the groundwater wells - such as the hydrophobic covers over liners or hydrophobic dyes used for a visual detection of the presence or absence of DNAPL. Both of these techniques are described in the ITRC guidance, "Integrated DNAPL Site Characterization and Tools Section" (May 2015). Please make a change to the evaluation of the presence of DNAPL and record the results in Table 2 "DNAPL Measurement Record" for all future groundwater monitoring reports.

Secondly, the PCLE maps in the quarterly reports need to adopt color-coding to depict concentrations for EDC. Also, PCLE maps for vinyl chloride need to be presented in each report, also with color-coding representing concentration levels. Vinyl chloride is a major daughter product from the natural break-down of tetrachloroethene (PCE) and trichloroethene. The 2015 groundwater monitoring data show increasing levels of vinyl chloride in the C zone at the VCM plant. [Well D-13 and D-14 screened at intervals 96 '– 106' and 106' – 116' respectively.] The concentration of vinyl chloride in well D-13 in 2015 was 0.25 parts per million (ppm), or converted to parts per billion (ppb) is equal to 250 ppb. The groundwater gradient in the C zone is to the east toward potential receptors, therefore vinyl chloride needs to be monitored and mapped, since the drinking water standard for vinyl chloride is 2 ppb. The data reveals that the source material for vinyl chloride has essentially moved from the A zone (which is showing a decreasing trend) to the lower B zone (which has concentrations of 9700 ppb.) The 2014 Performance Monitoring Plan (Section 2.2.3 Potential New Zone C Wells) describes two new wells to further define the eastern boundary of the impacts seen in well D-45 at the former Wastewater Treatment Plant [3.4 ppb vinyl chloride in 4th quarter 2015]. The EPA considers the installation of the monitoring well denoted D-49 in the PMP a priority for FPC. As such, the EPA expects FPC to submit a letter with a schedule for completion of this task (in lieu of deferring this activity to the schedule in the Post Closure Order as described in the Section 1.0 Introduction of the March 28, 2014 PMP).

Lastly, in our past meetings with TCEQ a potential recovery well for Zone C was discussed. Based on this groundwater review, the EPA is convinced that a recovery well in the lower B zone located at the VCM plant near well D-11 would be appropriate at this time. Additionally, as recommended in Section 7.4 of the 2015 4th Quarter Groundwater Monitoring report, well RD-3 redevelopment needs to be a priority for FPC. The EPA expects FPC to submit a letter in 30 days describing the location of a new recovery well for the lower B zone and a schedule for completion of the recovery well installation and RD-3 redevelopment.

If you have any questions or concerns, please feel free to contact me at 214.665.8385.

Nancy Fagan

Nancy Fagan

Project Coordinator

Attachment

cc: Hector Gonzales, Section Manager - Waste
TCEQ Region 14
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Corpus Christi, TX 78412

Ms. Maureen Hatfield, MC-127
TCEQ
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Formosa Plastics

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April 4, 2016

Via e-mail and Certified Mail:
7015 0640 0006 2456 9719

Ms. Nancy Fagan
Project Coordinator
6PD-O
U. S. Environmental Protection Agency
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

RE: Draft Corrective Measures Implementation Report
RCRA Docket No. VI-001(h)-90-H
3008(h) Administrative Order on Consent
EPA I. D. No. TXT490011293
Solid Waste Registration No. 31945

Dear Ms. Fagan:

Please find attached the Draft Corrective Measures Implementation Report. This document is being submitted as required by Amendment No. 2 to the 3008(h) Order, TASK XII: Corrective Measures Implementation.

If you have any questions about this report, please contact Matt Brogger at (361) 987- 7468 or by e-mail at mattb@ftpc.fpcusa.com.

Sincerely

Rick Crabtree
Vice President/General Manager
Formosa Plastics Corporation, Texas

Attachment

---

cc: Ms. Maureen Hatfield, (MC-127) Certified Mail: 7015 0640 0006 2456 9726
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March 24, 2016

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Ms. Nancy Fagan
Project Coordinator
6PD-O
U.S. Environmental Protection Agency
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

RE: Corrective Measures Implementation Progress Report
RCRA Docket No. VI-001(h)-90-H
Section 3008(h) Administrative Order on Consent, as Amended
EPA I.D. No. TXT490011293
Solid Waste Registration No. 31945

Dear Ms. Fagan:

As per Section V, Task XIV, of the Corrective Action Plan that was amended by Amendment No. 2 (effective on June 12, 2012) to the RCRA Section 3008(h) Order issued in 1991, FPC-TX is submitting its bi-monthly progress report for Corrective Measure Implementation (CMI) under the terms of the amended Order. We are continuing to use a progress report format that we have used for recent years for reports submitted under the Corrective Action Plan that was issued as Exhibit 1 to the 1991 Order. This report covers the time period between the date of the last progress report (January 22, 2016) and today's date. We understand that EPA wishes us to maintain the prior schedule and due dates under the amended Order, which would mean that these progress reports are due on the 25th of every other month.

Meetings and Conference Calls:

- None.

CMI Activities at FPC-TX in February 2016 and March 2016:

- None.

Planned CMI activities for the next reporting period:

- Submit the Draft CMI Report to EPA Region 6.

If you have any questions about this report please contact Matt Brogger at (361) 987-7468 or by e-mail at mattb@ftpc.fpcusa.com.

Sincerely,

Rick Crabtree
Vice President/General Manager
Formosa Plastics Corporation, Texas

cc: Ms. Susan Clewis — Certified Mail: 7015 0640 0006 2457 2351
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